POWER

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Licensing Engineers

SHALL the engineer be required to take out a license before he is permitted to practice—or to work?

There is a difference. The professional engineer "practices," the practical engineer "works."

But where practice commences and work leaves off, where the practical operator becomes the professional practitioner, it is not so easy to say.

And both groups are seeking to be licensed; that is to say, some people in each group are agitating for license laws and some are quietly or otherwise trying to head them off.

Some of the lesser lights want to be licensed like doctors and lawyers; some of the larger type object to being licensed like plumbers and dogs.

The real consideration is whether or not licensing engineers will conduce to the public welfare; not whether it will improve or prejudice the standing of the licensee.

When it is determined how the public is to benefit, it will be easier to say what the law should provide for and how inclusive it should be.

From the point of view of safety it would seem that some sort of assurance should be had of the competency of those responsible for the design of bridges, buildings, dams and other structures, the failure of which would involve public peril; but regard for the public safety would equally advise assurance of the competency of the operator of a power plant in a teeming factory, department store or hotel.

New York City has a law that requires operating engineers and firemen to be licensed. New York State has a law going into effect May 5, which requires any person practicing or offering to practice professional engineering or land surveying to submit evidence that he is qualified so to practice and to be licensed. The professional engineer is defined as one "who holds himself out as able to do or who does the work that an engineer does in the planning, designing, constructing, inspecting and supervising of engineering work, or appliances involved in public or private projects, or in making investigations for proposed engineering projects."

This might be interpreted to include many power-plant engineers, and a lot of them are wondering if they are professional enough to come under the law.

F. R. Low

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Availability and Economics of Hydro-Electric Power for New York

Statement of the Problem—Approximation of Available Water Power and Cost—Requirements of Service and Evaluation of Hydro Power—Quality of Hydro-Service—Reliability of Long-Distance Transmission

AT A joint meeting of the Metropolitan sections of the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers and American Institute of Electrical Engineers, held in the Engineering Societies building, New York, March 21, the availability and economics of hydro-electric power for the New York-New Jersey Metropolitan district was discussed in a symposium consisting of five papers, abstracts from which are given herewith. Calvert Townley, Chairman of the New York Section of the A. I. E. E. presided and expressed the opinion that the engineers of the different societies have more things in common than otherwise, and this they are endeavoring to demonstrate by holding joint meetings. "This age," said Mr. Townley, "is distinguished by the substitution of mechanical for man and animal power. Vital to the City of New York is an adequate supply of power, and if the engineer does not give attention to this matter who will? It is for this purpose that this meeting has been called." In outlining the problem, F. W. Scheidenhelm said in part:

Co-ordinated Statement of the Problem

BY F. W. SCHEIDENHELM*

Without seeking to appraise relative importance, the following may be considered as among the principal obstacles to the use of hydro-electric power in the metropolitan district:

1. Limited information, or, more accurately, limited appreciation of the extent to which hydro-electric power can be made available and of the method of utilizing such power, especially in combination with steam-electric power.

2. Uncertainty or disagreement as to the relative cost of delivered hydro-electric power compared with the cost of steam-electric power performing the same service.

3. Doubt as to the quality of service on part of hydro plants and of connecting transmission lines.

4. Legal difficulties, as involving especially the means for acquiring necessary lands and rights.

5. Lack of definite and continuing policy on part of the states concerned.

METHOD OF UTILIZATION IN COMBINATION WITH STEAM POWER

For the New York-New Jersey metropolitan district the problem is essentially one of utilizing hydro-electric power in combination with large sources of steam-electric power supply. Certainly, use in combination is preferable.

For a clear understanding of methods of utilization one should distinguish between installed capacity and energy output. The total installation in a hydro plant may be considered in two classes, which, merely for convenience of reference, may be styled Classes 1 and 2.

Class 1 hydro capacity is that hydro capacity, measured at the point of delivery to the distribution system, which will obviate, or be a reliable substitute for, the installation of an equal capacity of steam-electric power.

Class 2 hydro capacity is the remainder of the total hydro installation; in other words, is that hydro capacity installed in addition to Class 1 capacity.

One aim in operating hydro capacity is to prevent the waste of any water which could be used to help carry load. Thus, during periods of high flow, the Class 2 capacity is used to whatever extent is necessary in supplementing Class 1 capacity for the purpose of preventing waste of otherwise utilizable stream flow. Under these conditions steam-electric capacity (equal in amount at least to the Class 2 hydro capacity) is released temporarily from load-carrying service and for the time being becomes the reserve capacity for the entire power system. During periods of low flow, on the other hand, it is Class 2 hydro capacity which becomes the reserve capacity of the combined system.

RECENT TENDENCY IN HYDRO DEVELOPMENT

In earlier days one was accustomed to consider the subject from the viewpoint of using steam-electric power as auxiliary to the hydro. Thus as regards both installed capacity and energy output the hydro power was usually preponderant. This is still true of the Niagara systems and of the major power systems of the Far West and the Southeast. However, in these portions of the East where power demand is tremendous and rapidly growing and where the readily available water power is not great in comparison, the newer developments logically are built or being planned from the viewpoint of making the hydro power supplement steam power as effectively as possible. Except where the natural flow is practically uniform and not subject to material artificial regulation, as in the case of the Niagara River, the result is the installation of considerably greater hydro capacity under conditions of combined hydro and steam operation than if the same water power were to be developed to serve an independent market.

As an example of this so-called over-development Mr. Scheidenhelm referred to the Salmon River installation of the Niagara, Lockport & Ontario Power Co. This installation of 26,000 kw. is approximately 325 per cent of the average power, which the site affords, or probably about twice the capacity that would be warranted for an independent development of the site.

In addition to the incidental effect with regard to the conservation of fuel resources, the utilization of hydro power would bring certain more immediate advantages.

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In the first place, if the utilization were practicable at all, it would undoubtedly be because financial economies would result. Such economies would be due, not merely to the very low operating costs of hydro plants as compared with steam, but also to the fact that the fixed charges per dollar of investment average about 20 to 40 per cent more for steam developments than for hydro. Taxes are generally lower and depreciation very much lower. In this connection it should be borne in mind that any present economies would be augmented in the future because of the practical certainty that coal costs will gradually increase concurrently with the depletion in coal supplies.

Then there is the effect of "white coal" in easing somewhat the congestion on railroads. On coal-mining situations, such as experienced during the past winter, there would be a beneficial effect, especially in that in the pertinent latitudes the prolonged low-water season is not coincident with the season of greatest demand for coal. Moreover, the seasons of prolonged low flow terminate in general before the period of annual peak demand for power.

For combined systems, such as would obtain in our metropolitan district, there would be the increased assurance of continuous service which results from diversity of sources of power supply. Thus the possible ill effects of labor difficulties at the coal mines, on the railroads or in the steam-electric power plants themselves would be considerably mitigated as compared with systems relying entirely on steam-electric power.

Inadvisability of Political Barriers

Greater New York and Westchester County are separable from northeastern New Jersey only on political not economic grounds. The Hudson River is not a barrier in itself. It happens that on each side of the river the power market is such that it could independently utilize large quantities of hydro power, whether that be high load-factor power from the Niagara and the St. Lawrence or low load-factor power from an interior stream. Nevertheless, it is clear that, in order to obtain the fullest benefits from the use of hydro power, state boundaries should not be allowed to become barriers to proper economic development.

Available Water Power and Cost of Delivery

By W. S. Murray*

The Superpower Report was presented to the public in the latter part of 1921. The system it discussed and recommended carried with it no import that that system should take form as an incorporated company of special identity. Superpower can be correctly described as a "formula of procedure." Long before the idea of superpower system had presented itself to me, the electrical utilities had been proceeding in a direction to suggest just such a plan. It is with considerable satisfaction that the engineers associated with the Superpower Survey see ratification of their power map now under way. This map shows load centers and points of steam-electric and hydro-electric power supply which, based on the rate of load growths, would appear as economically right in 1930.

The advantage of steam-electric power in association with hydro-electric power cannot be better brought out than in the case of the Delaware River. Developed independently and in parts, it is questionable whether the energy so produced would be economical, but when associated with steam-electric power and completely developed at one time, it becomes practicable.

Referring to the hydro-electric possibilities that are at or within 200 miles from the New York or New Jersey load centers, the Hudson River powers are just about in touch with this distance, while the Delaware and Susquehanna are within. Except, therefore, that we may consider the Potomac and Connecticut Rivers (much of the energy from which can be locally absorbed) as relay power, this leaves for our consideration the first three. However, before discussing these rivers, it is of importance to say that as some transmission distance is involved, this adds materially to their per kilowatt-year cost or hour when measured at the point of power receipt. It is therefore of importance that a maximum of energy (kw.-hr.) be derived from these developments that its unit cost may be reduced. In this connection the impounding of waters in reservoirs is very important.

Susquehanna River

The drainage area of the Susquehanna above Harrisburg is 24,100 square miles. In flood periods its discharge reaches 700,000 sec.-ft., while in the dry season it falls to as low as 2,000 sec.-ft. Unfortunately, there are no favorable sites for storage reservoirs, in consequence of which only what has become known as "run of river" power is available. However, taking advantage of an association with steam-electric development and notwithstanding the low-flow period of 2,000 sec.-ft., it would be economical—utilizing 174 ft. of the head that exists between Harrisburg and the sea—to develop by 1930 plant capacity to the extent of 185,000 kw., and in an average year such a development would produce 1,230,000,000 kw.-hr., while in a minimum year this would fall to 900,000,000 kw.-hr. When the energy of an average year is absorbed within the composite superpower system, the cost per kilowatt-hour at the river will be about 4 mills, and while the power could be used as relay to more distant points, its immediate and more constant markets would be Harrisburg and Baltimore. The total capacity as now developed on the Susquehanna is 83,500 kw., which should be increased in 1930 by approximately 100,000 kw., and in more distant years it is very probable that, using the total available head of 204 ft., a total capacity of 620,000 kw. will be justified, and this will be due only to the enormous energy absorptive powers of the then much enlarged superpower system, such a demand calling for a flow of 45,000 sec.-ft. through the waterwheels.

Delaware River

The hydro-electric characteristics of the Delaware River are the reverse of those of the Susquehanna, for while the Susquehanna can furnish only the so-called "run of river" power, the Delaware is fundamentally a storage river. There are eight impounding reservoirs (not yet constructed) in which an aggregate of 50,000,000,000 cu.ft. of water could be stored. As of 1930, it would appear to be economical to develop 350,000 kw., and such a capacity would produce during an average year, 1,250,000,000 kw.-hr., and for a minimum year 985,000,000 kw.-hr. For an average year the approximate cost of this power as measured at the river would be slightly more than 6 mills, and while this is higher than for the Susquehanna River, it is

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none the less attractive on account of the storage feature, for under peak conditions of load, power could be delivered at less cost than from steam plants and furthermore, with the peak lifted from the steam plants, their load factors will be increased, thus lowering the unit cost of steam-produced power. The market for the Delaware power will be the New York and New Jersey load centers, the anthracite region, and Philadelphia doubtless at times will offer opportunity for economic absorption.

There are no developments at present on the Delaware River. As of 1930, a total plant capacity of 350,000 kw. would be justified—this capacity increasing to 668,500 kw. with the ultimate expansion of the superpower system.

Hudson River

Like the Delaware River, the Hudson offers valuable storage opportunities. There are four points where water can be impounded to an aggregate quantity of 63,000,000,000 cu.ft. In the case of the Delaware the impounded water, generally speaking, is more common to the points of power development than in the case of the Hudson and is therefore more effective.

As of 1930, it would appear to be economical to develop 150,000 kw., which capacity for an average year would supply 900,000,000 kw.-hr., and for a minimum year, 800,000,000 kw.-hr., the cost of which at the river for an average year would be slightly under 6 mills per kilowatt-hour. Under the conditions of ultimate expansion of the superpower system, it would appear that the Hudson River powers could be economically developed to a capacity of 430,000 kw. The first market for this power would naturally be Schenectady and points south on the superpower lines.

On account of the low development costs on the Niagara and St. Lawrence Rivers it seems probable that even inclusive of their longer transmission (300 miles), electric energy so derived can be placed within the New York and New Jersey load centers at less cost than that from the Hudson River. However, there is plenty of room within the confines of New York State to absorb this power.

In conclusion, I would say that in a recent intensive investigation to determine the cost of delivering power to the outlying districts of the New York and New Jersey load centers, it was found that a combination of steam and hydro-electric energy can be developed within a radius of 100 miles and delivered into the existing distribution systems at a cost not exceeding 7 mills, provided the load factor of the delivered power does not fall below 65 per cent. A block of 500,000 kw. could be made available in two years and increased to twice that amount if desired.

Requirements of Service for Hydro-Electric Power

By George A. Orrok*

For many years past a number of the utility companies in the Metropolitan area have been giving careful consideration to the expansion of their generating capacity, required by the rapidly growing demands being made upon them, and have included in their consideration the availability and practicability of the use of hydro-electric power, the location of generating stations at the mine mouth, and the possibility of reducing the rail-transportation congestion by pipe-line transmission of the fuel from the mines to the points of consumption.

Electricity supply companies of the metropolitan type sell a service, not a commodity; and every effort is made to secure an absolute continuity of service without break and at such times and quantities as the requirements or convenience of the public demand. The Edison system, as installed in all of our metropolitan centers, has a record of continuity which is assured by the large generating and storage-battery reserve carried by all companies using the system.

That there have been interruptions of service is true; however, the last and only serious interruption was caused by the burning of the Pearl Street generating station in 1893. Minor interruptions affecting one customer or a relatively small group of customers are of occasional local importance, but no failure of generating equipment affecting any large number of customers has occurred since that time.

Causes of Sudden Increases in Load

Worthy to be mentioned as adding to the difficulties of continuous service is the thunderstorm or snow-squall peak. One such peak occurred at 4 p.m. on March 2, 1911, when 52,000 kw. came on the system carrying a load of 75,000 kw. in 5 min. and disappeared during the following 10 minutes. The cause was a snow squall from the northwest. On June 20, 1919, around 3 p.m. when the system was carrying 180,000 kw., a thunderstorm added 133,000 kw. to the load in about 30 min. and did not entirely disappear until 5 p.m. The total load overtopped the winter peak by 15,000 kw. In this case about 40,000 kw. was carried by the storage batteries for a few minutes. Analogous to the thunderstorm peak, but not as troublesome, is the dark day. On Feb. 28, 1923, the load on the system increased from 120,000 kw. to 435,000 kw. in 2½ hours, an increase of nearly 3,000 kw. per minute, and this load persisted for more than eight hours.

Instability of Earlier Transmission Lines Made Hydro Power Unreliable

In the earlier reports the instability of transmission lines was considered a serious deterrent to the use of a hydro-electric source of power for the application in the Metropolitan district. Later improvements in the transmission art have apparently largely removed this difficulty and today I should not fear a break in the continuity of service from duplicate lines such as would of necessity be installed for this purpose, provided, of course, an adequate steam reserve is contemplated.

Every reasonably good water-bearing stream within 300 mi. of New York has been investigated and its power possibilities considered as a means of conservation of fuel and with regard to its applicability as a power supply to the New York problem. The water-power business has much of the speculative. Construction costs in the past have in many instances largely exceeded the estimates, due to unforeseen natural difficulties or excessive rainfall at undesirable times. In these cases much of the cost has to be written off, a dead loss, before dividends can be paid. And dividends are the only proof of a successful water-power plant.

Nevertheless and notwithstanding, hydro-electric power would be of advantage to the metropolitan dis-

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trict. Certainly for supplementing existing steam plants. Any reasonable amount of hydro-electric power at 50 per cent to 60 per cent load factor could be used and absorbed to good effect if the price was reasonable. Due regard must, of course, be given to the cost of connecting the hydro-electric power to the Metropolitan systems as most of the work must be underground and of very generous dimensions. The yearly charge for this purpose would be not far from $15 per kilowatt of demand to be expended locally, and this does not include the tie lines nor additional reactances and other possibly desirable machinery.

Use of Electricity Will Continue to Increase

The use of electricity in the Metropolitan districts will continue to increase at a rapid rate. In 1922 the electricity supply companies in the Metropolitan district generated 4,800,000,000 kw.-hr. with a peak of not far from 1,350,000 kw., a load factor of approximately 40 per cent. Substantially 90 per cent of this output was generated on about 50 per cent of the apparatus under actual operating conditions on less than 2 lb. of coal per kilowatt-hour. W. S. Murray, in the Superpower Report, very conservatively estimates this increase as 9 per cent annually, but says the growth has averaged 11 per cent annually. William Barclay Parsons two years ago estimated the increase at 12 per cent, and it is believed that this estimate was conservative. The output in 1930 of the Metropolitan district will probably run between 10 and 12 billion kilowatt-hours with a peak lying between 2,500,000 kw. and 3,000,000 kw. It is probable that not more than one-third of this load could be taken from water power in any event.

Any portion of this power of sufficient moment to pay for transmission could be absorbed by the Metropolitan district in the next few years. But to be attractive, the price, delivered at the outskirts of the district, must be low enough to take into consideration the increased operating and stand-by charges due to the reduced use of the steam generation plus the connection charges. Not sufficient importance has perhaps been assigned to the marked increase which results in operating costs when a considerable percentage of base power is cut out of steam-plant operation; the cream condition for efficient operation—the more considerable the amount of base power so assigned to water power, the larger the effect on the increased cost of operating the remainder of the load by steam.

Price at Which Hydro Power Is Attractive

Mr. Murray has mentioned 7 mills as the probable selling price of hydro-electric power delivered at the outskirts of the district. If there is added to this the connection cost of 2.5 mills the condition under which this current may be utilizable by the power companies can be roughly approximate. With coal at $8 a ton and a 60 per cent load factor, a price of 6 to 7 mills delivered at the district boundary seems to be, roughly, about the point where the hydro-power ceases to be attractive. With coal at a lower price or water which must of necessity be given a higher load factor, the limit of attractive price will be lower. Even at the figures given, the water seasonal variation must work in well with the district variation or there will be no economic advantage. The figures just given have been based on using as much water on the peak as possible, but even with this condition the night watch must waste water unless large diurnal storage is provided.

Factors Affecting Quality of Hydro-Electric Service

By F. A. Allner*

Hydro service, particularly in combination with steam plants for the power supply to large cities, has made great strides in the last ten years. I remember an occurrence of about ten years ago, when I was visiting the great metropolis of the Middle West. The operating executive of the 40,000-hp. municipal hydro-plant stated to me proudly, that under his management the service to the city had been raised to an efficiency of 99.7 per cent or so, if I remember correctly. Obviously, for an input-output or gross and net ratio, this would appear to be a very remarkable performance, but after an analysis of the statement it really meant only that during the 8,760 hours of the year there were over 26 hours when service was completely interrupted on the incoming end of the city substation.

Luckily, the foregoing method of expressing service quality is not the standard that public utilities, entrusted with the supply of power to the large cities, assume. As a matter of course that power must be continuous and first-class in every respect all the time, and a strict accounting must be given for every second that, for some reason or other, the 100 per cent standard is not maintained.

Troubles in Hydro-Electric Stations

It is to be expected that among the various troubles that are possible in a hydro plant, there will be some that are peculiar to hydro installations while others are similar to, or common with, trouble in any electric station. The character of hydraulic trouble will vary for different climates and for plants with extremely high or extremely low heads.

I have particularly in mind the type of plant that may possibly be called upon to contribute to the power supply for the Metropolitan district. The individual plants would rarely be below 50,000-hp. capacity, some of them going up as high as several hundred thousand horsepower. A few of the plants—particularly those of the larger capacity—would be base-load plants, utilizing a more or less steady flow; others would be developed primarily as peak plants with seasonal storage. There may also be some run-of-river developments. During high flow these latter plants would operate on base load; during low flow, on peaks. All the plants would be located in a northern climate.

Extremely high or extremely low river stages, would be peculiar to the run-of-river plants. A properly designed plant need not fear high-water conditions as it is quite customary not only to base the design on the highest ever recorded previous flood stage, but to allow for an additional margin of excess flow. Provision for a minimum flow is largely a question of economics and will never affect the question of service in a properly arranged scheme of development.

High flood stages may occasionally bring down floating matter, requiring special attention for cleaning the screens. This may cause a temporary small reduction in output. The reduction develops gradually and can easily be compensated for by increasing slightly the output at the steam plants.

The most important hydraulic trouble to guard

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against in the design and operation of plants that may serve the Metropolitan district, is ice trouble. There are different kinds of ice troubles, all of which may be met with in those plants. First and least serious is trouble from local ice; that is, from cake ice that has been formed in the forebay or in the canals leading to the plant. This ice may stay on during the entire winter season. It may break up, owing to expansion and contraction with the varying temperature, aided by fluctuations in forebay level, but it generally will stay in place until melted by warm weather. After this forebay ice has broken up in fragments the current may draw it under the submerged skimmer arches into the gatehouse against the screens, thus reducing the water flow. This is not a serious matter and can be remedied by releasing this cake ice through ice chutes, or by removing the most troublesome pieces with the gatehouse hoisting facilities.

Frazil Ice Causes Most Trouble

A second class of ice trouble refers to up-river ice, which is moved down from the creeks and tributaries into the main river and eventually will pass by the plant. In the process of its travel it may cause ice jams, but they will in general have little effect on the plant. As a rule, modern plants have their intakes arranged in such a manner that hardly any of the up-river ice will enter the forebay.

As to the third kind of ice trouble—that is, frazil and anchor ice—it creeps along stealthily and without display, but it is most dangerous. There are many ways possible to diagnose impending frazil ice runs, beginning with the study of climatological conditions, accurate readings of water temperatures, inspection of submerged test chains or other metal objects, observation of the behavior of small waterwheel-driven auxiliaries that operate accoustic or optic signaling devices, etc. The remedial steps consist in the raising of the screens, maintaining of highest possible temperature in gatehouse and power house, continuous movement of guide-vane mechanisms, steam or electric heating of those submerged metal parts where the ice is inclined to stick, etc.

Steam Plants Compared with Hydro-Electric

The comparison between the familiar power and service troubles in steam stations and those in hydro-electric plants is too inviting to be side-stepped. The steam plant must figure with all the conditions affecting the mining, transportation, delivery and storage of fuel, the varying grades of fuel, its passing through the bunkers, feeding into the stokers or burners, proper combustion, taking care of boilers and economizers, of cleaning of tubes inside and outside, of baffles and settings, blowers and fans, regulation of draft, dumping and removal of ashes, etc. The indirect transformation of the heat in the coal into the heat units of the evaporated water has to be dealt with. An elaborate system of feed-water supply, probably evaporators, boiler-feed pumps, feed-water heaters, deaërators, hot-well pumps, air-removal pumps, huge condensers with thousands of individual tube packings, and then the whole complicated apparatus that must be set up to handle the circulating water is included in the equipment. The steam plant requires continuous watchfulness and laboratory checks on fuel, on feed water, on a great variety of delicate instruments and gages, safety devices, etc.

Compared with this first process in the steam plant, the hydraulic plant relies on nature for its supply of white coal in a manner that is not subject to mine strikes, transportation tie-ups, or varying quality of fuel. No auxiliaries or intricate mechanisms of any kind are required, and hardly any hazard worth mentioning is involved in this first step, that cannot be met successfully in the modern hydro station. The few problems are of a recurring nature; that is, once solved, they are solved practically forever. At the steam plant a new kind of fuel will introduce a new problem that may affect not only efficiency, but also output and service.

It is true that a hydro plant once built cannot be changed or remodeled as readily as a steam plant. The latter can have defective or obsolete design or construction more easily corrected. On the other hand, the art of hydro-electric development and transmission work has advanced to a point where it is more nearly perfect, and in comparison more simple than even the most successful steam station design of our present period.

Comparable to the steam headers and to the pipe lines from boilers to headers and from headers to turbines are the intake flumes at the low-head hydraulic plants, and the steel penstocks in high-head plants. The excess pressure produced by sudden drop of load and the closing of the turbine gates is a problem that is well understood and can easily be taken care of in the design and operation of the plant. Bursting of penstocks or turbine casings is now a very rare occurrence.

The next step of the power-producing process refers to the transformation of the potential energy into mechanical work at the generator shaft. At the waterwheel this is a very simple mechanism controlled by a governor, ordinarily embodying only one auxiliary equipment; that is, the governor pump producing the operating pressure.

Hydraulic Turbines Are Reliable

The turbine runners, the operating mechanism, guide vanes and bearings are sturdy apparatus that rarely gives any trouble affecting output or service that cannot be taken care of by a simple system of inspection and preventative maintenance. The problem of erosion of runners and corrosion of submerged parts is also well understood and has become a matter of routine maintenance. The inspection of a turbine and its mechanism on the modern single-runner unit is a simple process and can be carried out thoroughly in less than 24 hours. A more complete overhauling, such as may be found advisable during a greater interval of years requires, of course, a longer time of outage, but not as long as the corresponding work on a steam turbine. The average outage for inspection and repairs at times when the unit could be employed usefully, is almost negligible.

At the steam plant there is the high-speed turbine runner rotating between minute clearances, axially and radially, with several thousands of rotating blades moving past several thousands of stationary blades. The waterwheel in nearly all cases can stand a complete runaway; that is, about double speed. In a steam turbine an overspeed of more than 15 per cent is considered dangerous, and a special governor, independent of the speed-regulating governor, is employed to disconnect the unit in case of over-speed.

On account of the large temperature differences, a slow and equal heating up of the huge turbine body is advisable before starting. Careful steam-plant operators figure with a heating up period of from one to two hours. Some less conservative ones are willing to chance it in one-half hour.

A waterwheel unit can be brought up from standstill to full load in less than half a minute. I believe 21 sec. is the record at the Holtwood plant. On one occasion during the 1922 low-flow period, when a 20,000-kw. steam unit failed and a second 20,000-kw. unit separated automatically from the bus, three 10,000-kw. hydro units were brought up to full load from standstill in 2 min. and 30 sec. from the same control board. No communication of any kind between steam and hydro plant operators preceded this paralleling other than the wavering of the frequency and other indications on the benchboard instruments. The necessary system capacity was restored much quicker than the part of the load that was lost could come back.

When operating in parallel with a run-of-river plant, the feeling of security on a combined hydro-steam system is greatest at times of low flow, because then one or more hydro units are available as spares, and if anything happens at the steam plant these spare units can be brought in so quickly that no load will be lost. The same condition applies to parallel operation with a peak hydro plant. On the other hand, during the high-flow period all the available hydro units are in service during the important peak hours, and in case of steam-turbine failure or other trouble on the steam system, commercial load must be cut off pending the bringing up of additional steam-turbine capacity, unless spare units are floated in at partial load in anticipation of such contingencies.

Quick Starting of Hydro-Electric Plant

In the matter of quick starting up the modern hydro plant has another great advantage over the same operation at the steam plant, which may become of great importance in certain emergencies, when the personnel of the plant is crippled by an accident or by other causes. The switchboard operator can start up and parallel a hydro unit single-handed from the control board, without the assistance of any other attendant. This frequently has been done at the Holtwood plant, as a matter of training, in less than four minutes.

Compare this with the multiplicity of operations when starting up a steam unit and getting cold boilers on the line, the many precautions to be observed, the long time and the number of men required on the different operating floors, etc.

The hydro generators, as a rule, are designed to withstand runaway speed the same as the waterwheels. The mechanical factors of safety are ample, and the designer has little difficulty in proportioning the electrical and mechanical design to best advantage for producing a rugged and simple, but yet very efficient machine, accessible and easy to inspect and maintain.

There is still room for further improvements not so much in the matter of hydro generation and transmission as in the matter of distribution and utilization, or the interconnection problem in the broader sense. This refers to trouble originating chiefly on the large city distribution systems, that cause generating stations to fall out of step, be they steam stations in the same city or hydro and steam plants connected by high-tension lines.

Reliability of Long-Distance Transmission

By Lorin E. Imlay*

If we should attempt to enumerate the different things that may happen to a steam-electric generating plant that may cause an interruption to service, the result is a rather appalling list of possible casualties. Is it any wonder that Boston had an interruption to a large percentage of its power a few months ago, or that Chicago had an almost complete shutdown two years ago? Partial shutdowns are not unknown, even in New York. Mention is made of these things here to show that not all of the failures or possibilities of failure are confined to long-distance lines. Yet with all these sinister possibilities in the background, the service in our large cities is good and is growing better year by year. Likewise long-distance service is good and is growing better and better year by year.

In any large city where electric service is supplied by steam generating units, there is a constant shifting over and changing the load from one boiler to another, from one generating unit to another, and sometimes from one power house to another, in order to maintain the equipment and make necessary repairs. The net result is a practically constant service. No single unit could be depended on to produce this result. In making a comparison between the reliability of local steam-generated power and hydro-generated power brought in from a distance, this fact should be considered. Reliability of the hydro-electric energy, which is brought in as a single unit, is comparable with the reliability of the service to be obtained from a single steam unit of the same capacity, and not with the reliability obtained from the steam-electric generating system as a whole, in which many units are involved, which may be changed as occasion demands.

Transmission Lines Compared to Steam Units

In 1919 the installed capacity of steam-generating units in the New York load center was about 1,300,000 kw. If at that time 100,000 kw., or 8 per cent of the generating capacity available to supply New York and adjacent cities, had consisted of hydro-electric plants on the Delaware River 60 miles away and had been equipped to transmit this power to New York over two separate circuits, each having a capacity of 50,000 kw., I believe no experienced operating engineer would regard these units of hydro-electric energy, transmitted across the State of New Jersey, as less reliable than the output of any two 50,000-kw. steam turbines that may have been located in New York City.

When New York City is supplied with energy from long-distance sources over properly subdivided circuits from the bituminous mines, anthracite mines, St. Lawrence River, Niagara River, Adirondack rivers and the Delaware River, the risk of shutdown on any one unit will be no greater than the risk of shutdown on any single steam-generating unit of like capacity in local plants.

It is fair to inquire about the service that is now and has been for several years supplied over long-distance transmission lines. Between the 1st of August, 1899, and November 26, 1916, the Buffalo General Electric Co., furnishing the light and power service in the City of Buffalo, was supplied with energy from Niagara Falls over about 200 miles of overhead circuits. During this period of over 16 years the only stand-by service

*Consulting engineer, Niagara Falls Power Company.

in Buffalo was about 6,000 kw. of 500-volt steam-electric capacity owned by the street railway company. During this period the Buffalo demand increased from 12,000 to 66,000 kw. In 1916 the Buffalo company started its new steam plant, which was installed solely because no further power could be supplied from Niagara Falls on account of the federal government's limitation on the diversion of water from the Niagara River.

The City of Syracuse requires about 45,000-kw. and is supplied by the Niagara, Lockport & Ontario Power Co., over two circuits from Niagara Falls 160 miles away, two circuits from Salmon River, about 40 miles away, and one circuit from the steam plant at Lyons, about 45 miles away: All the service to the city, as well as a number of important manufacturing companies, are supplied over long-distance lines, and there is no stand-by service.

This transmission company supplied annually 85,000,000 kw.-hr. to transportation companies which have no relay service, 200,000,000 kw.-hr. to other distributing companies with no power generation facilities of their own, 50,000,000 kw.-hr. to industries with no power generating facilities of their own, 50,000,000 kw.-hr. to industries with no other power equipment, and 32,000,000 kw.-hr. to the Lackawanna Steel Co., which does not provide relay service for its transmitted power. The chief engineer of the company recently told the writer that nearly all of the company's lines are now insulated for 110,000 volts, which practically eliminates troubles from lightning. The working voltage is 60,000, but this will soon be raised to 110,000 volts.

We must go to Canada for the best examples of large municipalities depending on energy transmitted from hydro-electric generating plants. In 1920 the total installed capacity of waterwheels in electric utility plants in Canada was 1,310,000 kw. The installed capacity of steam engines and turbines and electric utility plants was 193,000 kw., or 15 per cent of the capacity of the hydro-operated generating plants. In the province of Ontario the percentage of steam-generating capacity was 8 per cent and in Quebec 5.3 per cent. In the last two years this percentage must have appreciably decreased as several large hydro plants have recently been started in Ontario and Quebec, and it is doubtful whether any steam-operated utility plants have been installed anywhere in the Dominion within that period.

Discussion

John P. Hogan:[1] The opinion has been expressed that state boundaries should not be allowed to govern water-power developments. I would like to advance the thought that perhaps national boundaries ought not to be considered. The St. Lawrence is not developed, and New England cities and New York have a deep interest in its development, and they are being held back in their development by a national line.

In regard to power which is available for the Metropolitan district, we have the intermittent power on interior streams, power that can be regulated by storage and the great powers on the continuous streams, Niagara and St. Lawrence. Of these the most valuable power located close enough to the city, is that on interior streams that are susceptible of regulation by storage, because in that way a continuous peak capacity can be made available. However, it must be considered that in developing power on intermittent streams, whether they be regulated or not, these powers must be located fairly close to load centers, because if they are not, long-distance and expensive transmission is involved and the only way to pay the transmission costs is by using the lines to the greatest possible limit. Therefore, the only powers at any distance that may be economically used in the Metropolitan district, are those powers that are practically continuous and that can be delivered in the city at a relatively high load factor.

It is worthy of consideration in connection with the intermittent powers, either those on the Hudson or those in the adjacent territory, which has a market of its own, that at times of low water the transmission line might possibly be used for the purpose of taking some power out of New York City and sending it back to the territory from which the water power was supplied.

W. S. Finlay, Jr.[2]: There are two prime factors in New York City's problem of power supply from hydro sources, and that is whether the people are going to continue to demand the character of service that is now being supplied and whether they are going to be willing to continue to pay for it. New York demands something that is apparently inconceivable to the average citizen of many of our great cities, particularly in the West and Canada, such as have been supplied with hydro power and are living comfortably and happily so far as electric service is concerned.

What we shall have to face in New York is a period of education as to what is wanted for a dollar. Is the present standard of service wanted or are we going to attempt to get what can be obtained from some other source and possibly save something? There is no question as to the matter of reliability in getting hydro power here. As to whether that reliability measures up with our present set standards or not is a matter for serious consideration. In the outlying districts around the city, manufacturers and domestic consumers will probably be content with service that can be given them at a lower cost, which might involve an occasional interruption, such as occurs in many of the Western cities of fairly large size. But whether New York City will be content with this or not is one of the big problems.

Mr. Murray has pointed out that hydro power at best could theoretically furnish in 1930 under 30 per cent of the Metropolitan District's total requirements with all the interior resources of New York developed. With the present rate of increase, by 1960 it would be rather doubtful whether hydro could supply more than 5 per cent of such total. If such is the case, it is necessary to devote our energies to securing the greatest efficiency through the development of steam-power apparatus, or some other hitherto undeveloped means of developing energy to get the best for our dollar in steam-power supply or relatively handicap the district's commercial development. What hydro power there will be available will be of the greatest service.

Briefly summarized, the problem of the Metropolitan District is to decide as to the character of service it considers necessary to its welfare and comfort, recognizing the cost to be paid and then to bend every effort to the conservation of its resources and the maintenance and development of such resources as affect its power service and supply, if it at all hopes to continue as the country's greatest industrial and commercial center.

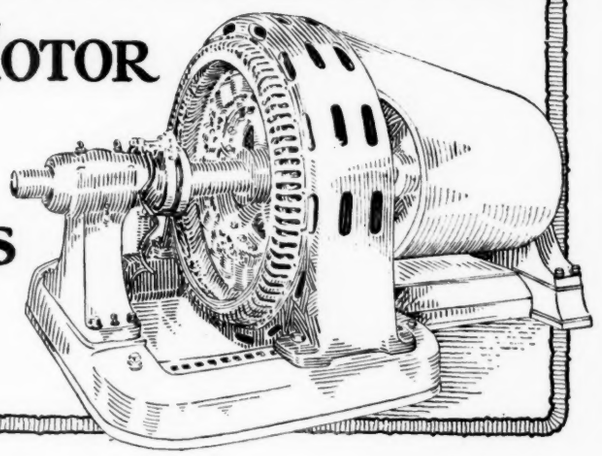
[1] Consulting engineer with William Barclay Parsons, New York City.

[2] Vice-President, American Water Works & Electric Co.

THE SYNCHRONOUS MOTOR *and* HOW IT OPERATES

by

GORDON FOX*



IF AN alternating-current generator be connected to a suitable supply system and if the prime mover of this alternator be shut off, the set will continue to rotate, the electric unit driving the engine. When the machine is operated as a generator, the torque of the electric unit opposes that of the prime mover. When the driving power of the prime mover is discontinued, the electric unit produces torque and becomes what is known as a synchronous motor, to maintain the rotation in its original direction. A synchronous motor is, in theory, a synchronous alternator (alternating-current generator) receiving instead of producing electric energy.

The stator of a synchronous motor is similar to that of an induction motor. It presents a smooth bore and carries distributed phase windings, Fig. 1. The rotor comprises a number of radial polepieces, Fig. 2, mag-

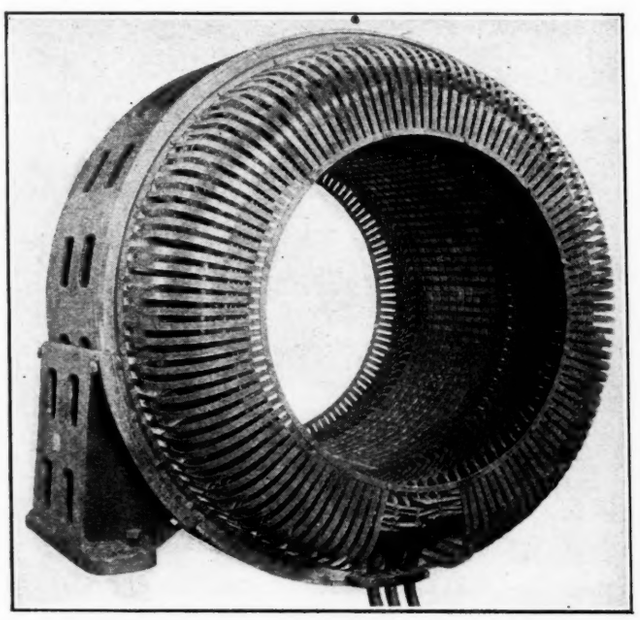


FIG. 1—STATOR OF SYNCHRONOUS MOTOR

netized by coils carrying direct current introduced through collector rings *R*.

The action of the synchronous motor may be considered as based on the fact that magnetic poles of unlike polarity attract each other. The number of rotor poles corresponds to the number of poles per phase in the stator winding. Each south pole of the rotor tends to take a position directly opposite a north pole of the

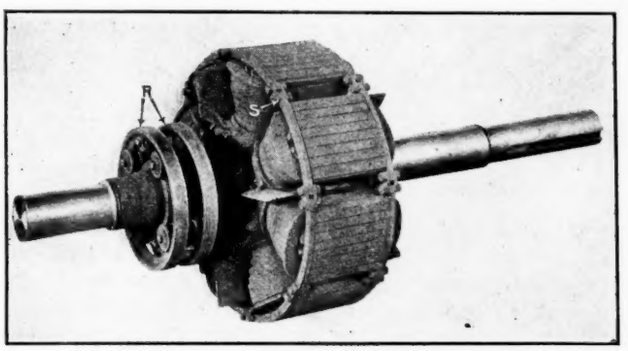


FIG. 2—ROTOR OF SYNCHRONOUS MOTOR

stator and vice versa, as indicated in Fig. 3. The magnetic field of the stator revolves at synchronous speed in the same manner as that of an induction motor. The rotor poles then must also revolve at the same speed in order to maintain their position in the stator field. The rotor must revolve in exact synchronism with the revolving field of the stator if torque in one direction is to be obtained. At any other speed the torque at one instant will be forward, the next instant reversed. The synchronous motor derives its name from the fact that the rotor revolves at synchronous speed regardless of the load.

The torque developed by the motor is adjusted to the external load according to the relative position taken by the field or rotor poles with respect to the stator conductors when the current of the latter is passing through its maximum value. When the motor is running light, the axis of the rotor poles approximately coincides with the axis of the stator poles, as indicated in Fig. 3. When load is added, the rotor lags slightly, not in speed but in angular position, so that the rotor poles take an intermediate location, as shown in Fig. 4. The torque developed as the rotor poles are angularly displaced, increases with the displacement provided this does not exceed 90 electrical degrees. Beyond this point the torque-producing power diminishes and the motor pulls out of step and stops.

The revolving field in an induction motor is set up

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by magnetizing currents in the distributed stator windings. A synchronous motor will set up a revolving field in a similar manner. It has already been pointed out that a north pole of the rotor will approximately coincide with a south pole of the stator, thus the rotor field favors the stator field. The stator tends to maintain a field of nearly fixed value just as the primary magnetism of an induction motor is held constant. If the rotor's magnetizing influence is sufficiently strong

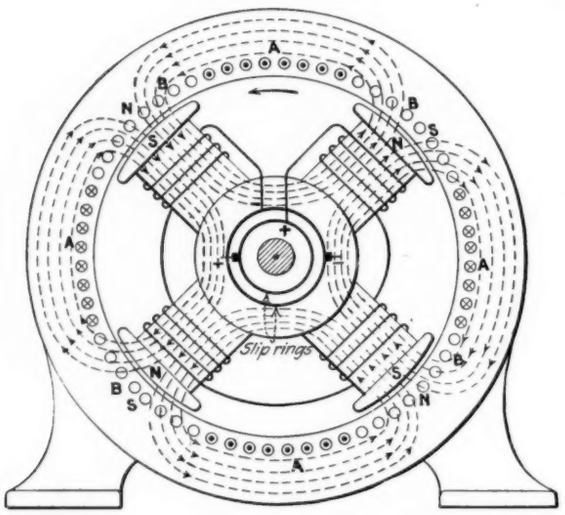


FIG. 3—DIAGRAM SHOWING RELATION BETWEEN STATOR AND ROTOR POLES AT NO LOAD

to set up a field of the desired value, then no magnetizing influence is required of the stator. In this case the countervoltage generated in the stator is of such value and phase relation, with respect to the impressed voltage, that no magnetizing current flow is produced. If the magnetizing influence of the rotor is insufficient to set up a field to generate the required countervoltage in the stator windings, a lagging magnetizing current flows as a result of the voltage difference, and supplies the deficiency in field magnetization. If the rotor fields be strongly excited, then the voltage generated in the stator windings may exceed the impressed voltage by a small amount. The voltage difference is then such as to set up a leading magnetizing current, but the direction of this current flow is reversed and tends to counteract the excess field magnetization and restrict the flux to a fixed value. It will thus be seen that, when the rotor field coils of a synchronous motor are weakly excited, the deficiency in magnetization is supplied by lagging wattless current taken from the alternating-current system. If the rotor fields be over-excited, a leading wattless current will be taken.

The angular position taken by the rotor poles, with respect to the stator field, depends not alone upon the motor torque, but is also influenced by the excitation and by the impressed voltage. If the rotor field poles be heavily excited, the rotor will lag less, to develop a given torque, than if the fields be weak. Increasing the impressed voltage on the stator windings produces a higher magnetization, which also minimizes the rotor lag for a given torque production.

A synchronous motor's speed is the same as that of the revolving field. This is determined, as in the induction motor, by the circuit frequency and the number of poles per phase in the stator winding, the speed being equal to 120 times the cycles per second divided by the number of poles. On a circuit of fixed frequency the synchronous speed is constant and the motor operates at this speed regardless of load up to its point of maximum torque or pull-out.

The direction of rotation is determined by the direction of the revolving field. This, in turn, is governed by the phase relations in the stator windings, just as in the induction motor. A three-phase motor may be reversed by interchange of any two stator leads. Reversal of the direct-current field leads does not affect the rotation, but merely influences the angular position of the rotor to the extent of one pole space.

Exciting current necessary for the rotor fields may be taken from any suitable direct-current supply. More commonly a small exciter is provided, either directly or belt-driven by the motor. Synchronous motors driving direct-current generators, commonly take their excitation from the direct-current end of the set where the voltage does not exceed 550. For reasons later explained, 125-volt excitation may be preferable to excitation at higher voltages. A field rheostat is always supplied in the exciter or motor field circuits, or both, for adjustment of the excitation. It is possible to govern the power factor of the motor by adjusting the field current. This is one of the most important characteristics of the synchronous motor.

Synchronous motors may be operated to carry mechanical load only. They may be operated as synchronous condensers for power-factor correction, with no mechanical load, or they may perform both services simultaneously; that is, drive mechanical load and be used for power-factor correction at the same time. The degree of excitation required depends upon the service for which the machine is intended. When operated to carry mechanical load only, its field is best excited to such

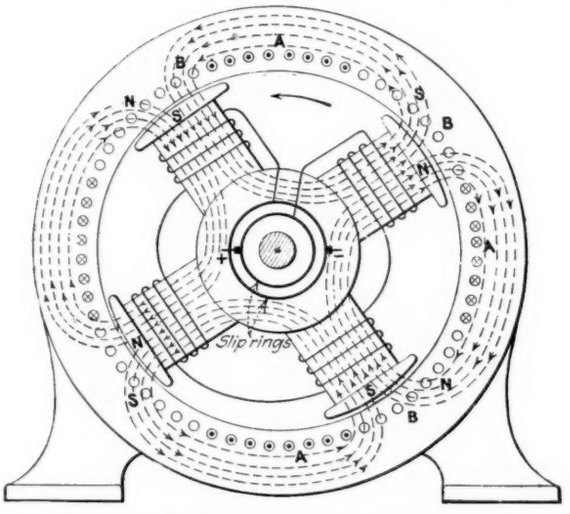


FIG. 4—RELATION BETWEEN ROTOR AND STATOR POLES WHEN MOTOR IS LOADED

a point that the power factor is unity at full load. The absence of wattless current permits minimum current input and highest efficiency under these conditions. As the mechanical load changes, the power factor will vary slightly. A machine may have a slightly leading power factor with a given excitation under light load. As the load increases, the rotor poles fall back so that they are not so nearly opposite the stator poles, their magnetizing influence is less effective, and unity-power-factor conditions will then be approached. Still further

increase of load may even cause a lagging current to flow; that is, the power factor will be less than unity lagging. Well-designed motors do not vary their power factor rapidly with changes of load. Since operation is more stable with over-excited fields and since the power factor tends to lag with increase of load, it is sometimes advisable to over-excite the fields slightly, particularly with fluctuating loads.

If a synchronous motor is to be operated idle, without load, for power-factor correction only, it may be built lighter in some respects, having a smaller shaft and bearings, for instance. Such a machine is not in reality a motor at all, being more correctly termed a synchronous condenser. The field excitation may be varied to such an extent that the armature current attains its full rated value, being almost entirely wattless. In this case the condenser exerts its maximum corrective influence and operates at almost zero power factor. If it is simply desired to raise the power factor of a system to a definite value, the excitation may be adjusted for a lesser amount of wattless current, just sufficient to accomplish the purpose. If the power factor of the system varies, this adjustment may be made automatically, if desired, by means of a voltage regulator.

Synchronous motors that are to be used to drive a mechanical load with no power-factor correction other than that resulting from addition of unity-power-factor load to the system, are rated on a 100 per cent power-factor basis. Motors that are to be used for combination service are commonly rated on the basis of kilovolt-ampere input at 80 per cent power factor.

If a synchronous motor is to be used for combination service, to carry a mechanical load and also to correct the power factor, it must be larger than if it were to perform either service alone. When operating near 100 per cent power factor, the capacity of the motor is limited by the heating of the stator conductors. When operating with leading power factor, the capacity is

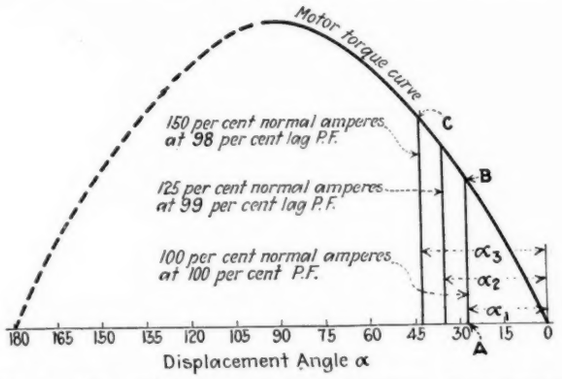

Motor torque curve
150 per cent normal amperes at 98 per cent lag P.F.
125 per cent normal amperes at 99 per cent lag P.F.
100 per cent normal amperes at 100 per cent P.F.
C
B
A
α_3
α_2
α_1
180 165 150 135 120 105 90 75 60 45 30 15 0
Displacement Angle α

FIG. 5—RELATION OF TORQUE TO ANGULAR POSITION OF FIELD POLES

limited more by field heating. When the machine is carrying load at 100 per cent power factor, no wattless current is involved, so that the current is all effective in producing mechanical output. Operating as a synchronous condenser at low power factor, the current is nearly all wattless. With combined service both load and wattless components exist. A combination unit is most effective when carrying some mechanical load. The exact relation as to mechanical load and wattless component which will give maximum corrective influence is affected by the size and power factor of the system to which the motor is connected. Combination service is efficient in that dual purposes are accomplished in a single unit almost as effectively as if the unit were used for but one service.

As previously stated, increase of torque demand causes the rotor to lag and the displacement angle to increase. This relation is illustrated in Fig. 5. From this curve it will be seen that with 100 per cent full-load amperes at 100 per cent power factor the torque is

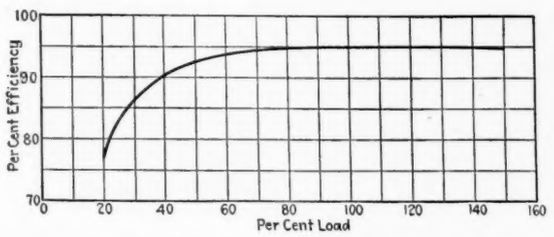


FIG. 6—EFFICIENCY LOAD CURVE OF 750-HP. 720-R.P.M. 60-CYCLE SYNCHRONOUS MOTOR

represented by the vertical distance *AB*. Increasing the load on the motor to where the current increases to 150 per full-load value, the power factor is 98 per cent lagging and the increase in torque is represented by the vertical distance from *B* to *C*. This does not represent a 50 per cent increase in torque for 50 per cent increase in current, but only about 40 per cent increase in torque, which shows that as the displacement angle increases between the stator and rotor poles, the torque produced per ampere armature current decreases. When a displacement of 90 deg. is reached, the motor exerts its maximum or pull-out torque.

In a synchronous motor the maximum torque developed is increased materially if the fields be strongly excited, since the displacement angle for a given torque is decreased and greater torque is thus required to cause a 90-deg. displacement. The maximum torque, with fixed excitation, varies directly as the impressed voltage. If the excitation is varied to correspond with the variation in applied voltage, the maximum torque varies as the square of the impressed voltage. In a motor with fixed excitation, the usual case, a drop in voltage causes the motor to draw leading current and assume an over-excited condition which tends to maintain the driving torque so that the decrease is less rapid than in the case of an induction motor. This gives the synchronous motor some advantage where the line voltage is unsteady.

Synchronous motors operated at unity power factor commonly develop 200 to 300 per cent full-load torque before pulling out. They will withstand a considerably higher torque momentarily than if gradually applied. Unnecessarily high pull-out torque is not desirable, as it is usually obtained at the sacrificed of other characteristics. The ordinary synchronous motor is limited in rating principally by the field heating. The requirement of heavy overload torques usually necessitates increased field flux, larger magnetic circuit and heavier field copper, hence may involve a larger frame and higher cost. Similar requirements arise in motors operated over-excited for power-factor correction.

The synchronous motor is a good machine from the viewpoint of efficiency. It has a sustained high efficiency over a rather wide range of loads as indicated in Fig. 6. It ordinarily excels the induction motor in this respect, the difference being particularly marked

in the case of low-speed machines. This characteristic is of especial advantage in large, constantly loaded equipments such as fans and pumps. In Fig. 7 are shown the full-load efficiencies of a line of synchronous motors when operated at 100 per cent power factor. Fig. 8 shows similar data for motors operated at 80 per cent leading power factor.

The modern motor is quite satisfactory in the matter of stability. As previously stated, it has a pull-out torque of 200 to 300 per cent normal. It maintains its speed until this point is reached. The motor is able to follow ordinary changes in frequency and will carry a moderate load with a frequency as much as 20 per cent below normal. Hunting due to frequency changes is not ordinarily troublesome, but may occasionally arise from combinations resulting from variations in angular velocity of synchronous apparatus on a system. The squirrel-cage winding *S*, Fig. 2, on the rotor ordinarily damps out any material tendency to hunting.

The greatest advantage of the synchronous motor is its high power factor and its value for power-factor correction. Its constant and maintained speed is sometimes an important benefit. The high and well-maintained efficiency is advantageous. This type of motor is well adapted for use on high-voltage lines, as its stator is usually built with fewer and larger slots than are used for the induction motor and therefore the windings are easier to insulate. The rotor carries a low-voltage winding only and is of strong construction. The motor has a relatively wide air gap. In the larger sizes and lower speeds, it may be cheaper than the equivalent induction motor. The synchronous motor generates a definite countervoltage and thus tends to maintain the voltage of the supply system. If desired, a voltage regulator may be supplied and arranged to cause the motor to maintain constant voltage within the limits of its capacity. The synchronous motor also

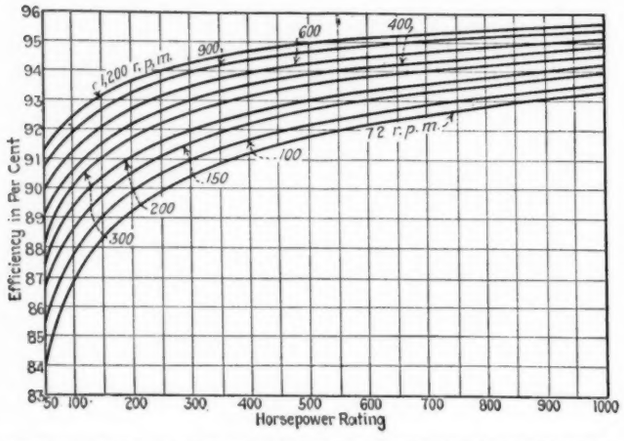


FIG. 7—FULL-LOAD EFFICIENCY CURVES OF SYNCHRONOUS MOTORS OPERATING AT 100 PER CENT POWER FACTOR

tends to balance the voltages in the different phases of an unbalanced system.

The motor has a number of inherent disadvantages. Among the foremost of these is the natural deficiency in pull-in torque and the heavy, lagging current taken in starting. The machine is less simple than the induction motor and requires perhaps a little higher-grade attention. As the speed cannot be varied, this motor is suited to constant-speed drives alone. It requires an exciter or excitation from a separate source. The control equipment is a little more complex than for an induction motor. Notably in the smaller sizes and higher speeds the cost is relatively high. Collector rings are required, but they give little trouble. When installing motors of this type, cognizance must be taken of the fact that they increase the amount of synchronous apparatus connected to a system and thus influence the required rupturing capacity of switching

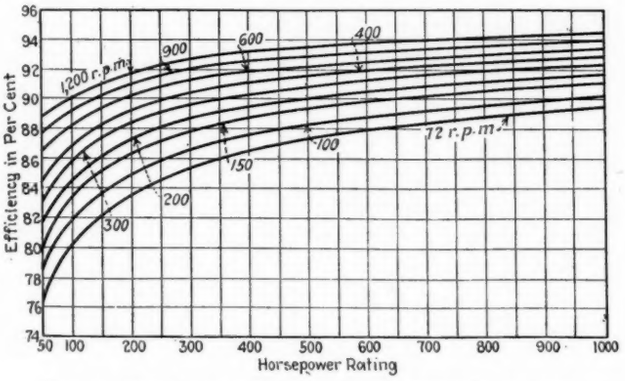


FIG. 8—FULL-LOAD EFFICIENCY CURVES OF SYNCHRONOUS MOTORS OPERATING AT 80 PER CENT POWER FACTOR

equipment. In case of interruption of power, unless of very short duration, the motor is liable to drop back sufficiently to fall out of step.

The synchronous motor may be adapted for dynamic braking. This is done by disconnecting the stator winding from the supply system and short-circuiting it through suitable resistance, at the same time applying reduced excitation. A braking effort exceeding full-load torque can be developed in this manner. This feature is of decided advantage in certain instances, as for some rubber-mill drives.

In applying synchronous motors it is desirable that care be exercised so that the voltage rating of the machine corresponds with the system voltage at the point of application. If a 2,200-volt motor be subjected to 2,400 volts, for instance, considerable excess direct-current excitatation will be required to obtain the desired power factor.

Synchronous motors are now available and in common use in sizes ranging from about 50 to 2,000 hp. and for speeds from 60 to 3,600 r.p.m. The great majority of motors installed range in size from 100 to 500 hp. and in speed from about 90 to 900 r.p.m. As previously indicated, the use of the synchronous motor is not ordinarily feasible in the smaller sizes and it compares particularly favorably with other types of motors at the lower speeds. The lower speed ratings mentioned apply to motors of large size. High-speed ratings are uncommon because the high-speed synchronous motor offers relatively small advantages over the equivalent induction motor and also because difficulties in constructing rotors with definite polepieces in the limited space and for high speeds add to the cost of such designs.

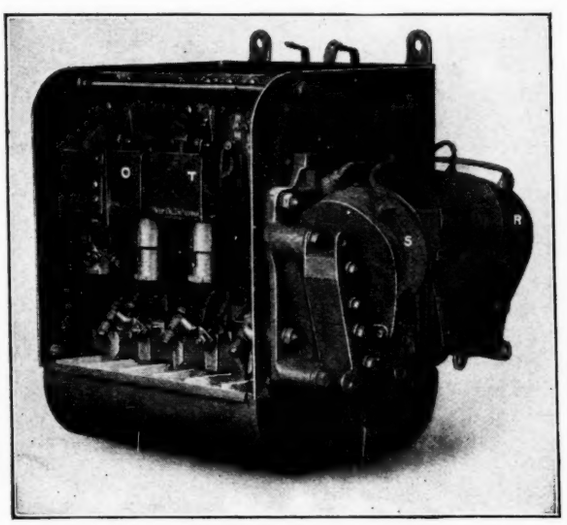
These motors are commonly used in motor-generator and frequency-converter sets. They are also applied for driving fans and blowers, centrifugal pumps, air and ammonia compressors, tube mills, flour mills, rubber mills, pulp grinders and jordans and for other similar applications where constant speed, continuous operation and infrequent and moderate starting require-

ments prevail. They are also finding some application as a sort of electrical gearing for maintenance of relative speeds of different machines, as in sectionalized paper-machine drive.

The so-called "synchronous-induction motor" is similar in all respects to a standard squirrel-cage induction motor except that the rotor is cut away to give a definite-pole construction. This motor starts as an induction motor and operates as a synchronous motor without direct-current excitation, the excitation being taken from the alternating-current system. It is thus entirely similar to the standard synchronous motor which pulls into step before excitation is applied. Motors of this type will not carry a heavy load. A notable application of this type of motor is in connection with mechanical rectifiers as used for electrical precipitation. These motors are of about 5-hp. rating and the load is light but synchronous speed is essential.

A New Automatic Auto-Starter for Squirrel-Cage Induction Motors

Automatic starters for squirrel-cage induction motors have been available for a number of years in various forms and styles, but the older types were in general large in dimensions, and not infrequently took up valuable space. A new type, shown in the figure, compact in size as well as reliable in operation, has been recently developed and placed on the market.



ASSEMBLED AUTO-STARTER WITH COVERS REMOVED

No experience or skill is required to operate the new starter, since it is not necessary to move a lever or handle in a definite direction or in a certain sequence. All that is required is to operate a master switch, various forms of which can be employed. For remote control by an operator, push buttons located at convenient points can be used. Full automatic operation, which obviates the necessity of an operator, is obtained by the use of a float switch or a pressure-gage relay, and thus the level of a liquid in an open tank or a certain pressure of a gas or liquid can be kept within predetermined limits.

Since the starter is automatic in operation, the motor is accelerated in a time that is consistent with the application and not according to the will of the operator. This gives the shortest time for safe acceleration and prevents auto-transformer burnouts and the abuse of the motor and the driven machinery. When the master switch is operated, the start magnet *S* is energized and the motor is connected through an auto-transformer to the line. After a definite time, determined by a time-limit accelerating relay *T*, the start magnet is de-energized and the run magnet *R*, energized. This operation opens the start contacts, which disconnect the motor from the auto-transformer and close the running contacts, connecting the motor directly to the line. When the stop button is pressed or the master switch operates to open the control circuit, the run magnet is de-energized, the run contacts open, and the motor is disconnected from the line and comes to a stop.

Overload protection on all phases is insured by a two-coil, overload relay *O*, connected in two of the phases. An inverse-time-limit arrangement prevents the overload relay from opening the circuit on instantaneous peak loads, but gives complete protection to the motor on any prolonged overload. The overload relay is fitted with a latch which prevents starting the motor after an overload until the relay has been reset electromagnetically by a reset push button. The control relay is given a definite time limit by means of a dashpot, so that the time of starting a motor can be adjusted for any period up to a maximum of 15 seconds.

The entire operating mechanism of the auto-starter is inclosed within a sheet-steel case so braced that it forms a rigid unity. The covers are arranged to be quickly and easily removed for installation and inspection purposes. The tank inclosing the contacts can be quickly dropped by releasing ring latches, thus exposing the contacts to view for inspection or replacement. This equipment is manufactured by the Westinghouse Electric & Manufacturing Company.

Bureau of Standards Tests Welded Tanks

The investigation of the strength of about fifty tanks, some of which had been welded by gas and some by electricity, has been completed by the Bureau of Standards. This work, which was carried out in co-operation with the American Bureau of Welding, was begun on Dec. 4 and completed on Feb. 9, and gives reliable information on the strength of welded tanks for the consideration of the Pressure Vessel Committee of the Boiler Code Committee of the A.S.M.E.

The results showed that double-V longitudinal welded seams are much stronger and more reliable than single-V welds. Recommendations were also made covering the design and construction of the heads. The pressures at which these tanks failed were so high that confidence in the safety of welded tanks that are properly constructed has been greatly increased. The method of testing, by hammering the weld while the tank is under a pressure of one and one-half times the working pressure, was discussed. Although this test did not prove as effective in showing up defective welds as had been hoped, its use is, nevertheless, justified.

Another acceptance test proposed in this report is to increase the pressure until the shell of the tank reaches the yield point. These tests show that the tanks are safe after being tested in this way. As it is probable that tanks having large outlets would be seriously deformed and, therefore, rendered unserviceable, this test is not likely to be adopted, but an increase in the test pressure will probably result.

Interior Treatment of Boiler Feed Water

By A. J. LOPPIN

WHILE it is generally best to treat hard make-up water before it is sent to the boilers, special conditions may warrant the use of treatment within the boiler. "Power" has recently and rather fully discussed the various methods of exterior treatment, so this article omits that phase of the subject, except in so far as it is needed for an understanding of the limitations and practical handling of interior treatment.

THERE are two general methods of treating hard boiler-feed water for the purpose of preventing the formation of scale. These are, first, exterior treatment, where the water is treated before feeding it into the boiler so that there remains in it none or very little of the scale-forming ingredients; and second, interior treatment, where the water is treated within the boiler.

Whether one or the other of the two methods should be used, depends entirely upon the conditions prevailing at the plant under consideration. It depends upon the amount and kind of scale-forming ingredients in the water, the amount of makeup water used, the course of the water from its source to the boiler, the period of operation of the boiler, the use of the steam, comparative first cost and maintenance cost for each system, type of boiler, rate of evaporation, pressure, load maintained, and all other factors having a bearing on the problem. It is a rare case where no treatment whatever is needed.

Where Interior Treatment Is Allowable

In small isolated plants exterior treatment may be prohibitive in first cost or inconvenient, and the interior treatment may have to be resorted to. Whether the latter *can* be used depends largely upon the quality of the water.

Indiscriminate use of so-called "boiler compounds" may be worse than no treatment at all. Like patent medicines, they are often sold as cure-alls. Water varies in its composition according to the locality in which it is found, and it is therefore obvious that what may be good for one water may not be good for another. Sometimes such compounds contain harmful ingredients, making matters worse instead of better.

It should be understood that chemicals or "compounds," when used in a boiler, do not prevent deposits in the boiler, but merely bring about certain chemical reactions that make the deposits less objectionable, in that they do not adhere to the metal as hard scale. In other words, the deposits are made of such a nature that they can be readily blown out. It must be borne in mind, therefore, that when a chemical is used in the boiler, the proper amount of blowing down must be resorted to in order to remove the deposits and prevent the salts in solution from becoming too concentrated. Otherwise, there is likely to be trouble by foaming.

There are two general problems with which we have to deal in determining what method of treatment shall be followed: First, that of the new plant where nothing is known with regard to the quality of the water, and second, that of an existing installation which is having trouble with scale. The latter is the more common of these two problems.

Water containing only bicarbonates in solution is said to contain "temporary hardness," because boiling will deposit the bicarbonates and make the water soft. Water containing sulphates, chlorides and nitrates is said to contain "permanent hardness," because boiling at atmospheric pressure will not remove them. In other words, heat up to 212 deg. will not remove them.

The only way to determine the exact composition of any water is to have an analysis made of it. This is absolutely necessary if the exterior treatment is to be followed. Table I shows the chief mineral compounds ordinarily found in water, together with their chemical

TABLE I—MOST COMMON MINERAL COMPOUNDS IN WATER

Name	Chemical Formula
(1) Calcium bicarbonate	$Ca(HCO_3)_2$
(2) Magnesium bicarbonate	$Mg(HCO_3)_2$
(3) Calcium sulphate	$CaSO_4$
(4) Magnesium sulphate	$MgSO_4$

formulas. In these formulas Ca stands for calcium, Mg for magnesium, S for sulphur, O for oxygen, H for hydrogen and C for carbon. This article deals mainly with these more common mineral elements.

Many other substances are found in solution in water, such as sodium bicarbonate and iron bicarbonate, various chlorides, nitrates, phosphates and oxides, but they are not found generally in such large quantities and are not as troublesome. All of these mineral compounds except the oxides, are technically called "salts." These dissolved compounds have various effects upon the water. The sulphates make a hard scale. The bicarbonates make a porous scale, which is not so objectionable as the sulphate scale by itself, but when bicarbonates are mixed with sulphates the combined scale is particularly bad. Calcium chloride is generally looked upon as an ingredient that causes foaming,

TABLE II—ROUGH CLASSIFICATION OF BOILER WATER

	Grains per U. S. Gallon	
Classification	Calcium Carbonate, Magnesium Carbonate, Magnesium Chloride	Calcium Sulphate Magnesium Sulphate
Very good	0 to 10	0 to 2.5
Good	10 to 15	2.5 to 4.0
Fair	15 to 20	4.0 to 5.0
Bad	20 to 30	5.0 to 7.5
Very bad	Over 30	Over 7.5

although there is some difference of opinion upon this point. Magnesium chloride forms a corrosive cementive scale and also tends to form hydrochloric acid and cause corrosion. Sodium carbonate in excess causes foaming, and upon decomposition is detrimental in its effect on shell plates.[1]

Table II gives the standard classification of boiler waters according to most authorities on the subject. Here the bicarbonates are given in terms of the amount of carbonates they would produce.

Boiler waters classified as "bad" or "very bad" should be treated by the exterior treatment. In other words, the scale-forming ingredients should be removed before

[1]There is still some difference of opinion as to whether the occasional embrittlement that has been observed in boilers is or is not due to an excess of sodium carbonate.

the water is used in the boiler. If the exterior treatment is to be carried out, the problem should be submitted to a consulting chemical engineer or some concern making a specialty of it, as the equipment for doing the purifying must be properly designed and the amounts of the chemicals properly regulated. The three general principles used in exterior treatment are as follows: (1) Heat treatment; (2) chemical treatment; (3) combination of both.

Principles of Exterior Treatment

There are advocates for each method and for each of the various systems, but after taking into consideration all the conditions existing at the plant where the water is to be treated, one system may be as good as another. On the other hand, one particular system or perhaps a combination of systems may be most effective.

Bicarbonates of calcium and magnesium are changed to carbonates in an open or closed heater, but usually only a part of them are deposited, as they do not remain in the heater long enough. The extent of the deposits depends on the capacity of the heater and the size of its settling chamber. Carbonates can be deposited more effectively from the cold water in tanks by the addition of lime. Sometimes the water is warmed to assist the process. A number of different systems embodying these principles are on the market.

Sulphate of calcium is practically insoluble above 300 deg. and, therefore, can be partly removed in a closed feed-water heater where live steam at 60 lb. pressure or higher is available and economical. This treatment will not remove the magnesium sulphate, which requires not only boiler temperatures, but also boiler concentrations to precipitate it. These sulphates can be more effectively removed by treating with sodium carbonate. Sodium carbonate is commonly known as "soda ash," "sal soda," "washing soda," "black ash," "scotch soda" or "soda crystals" and is very cheap. The "soda ash" converts the sulphates into carbonates which are insoluble and are precipitated. Sodium sulphate is also formed by this reaction, but is highly soluble and passes on into the boiler, where it is not troublesome unless it becomes concentrated, in which event it may cause foaming. This is avoided by regular blowing down.

"Caustic soda" or "caustic potash," technically known as sodium hydroxide and potassium hydroxide respectively, can also be used in treating magnesium sulphate, but they are not effective in treating calcium sulphate in exterior treatment. The reason they are not effective in this case is because they form calcium hydroxide (caustic lime), and this is quite as soluble as the calcium sulphate and would not be deposited.

Use of Soda for the Sulphates

The action of caustic soda on magnesium sulphate, however, is to form magnesium hydroxide, which is insoluble and would be deposited. Magnesium hydroxide is less soluble than the magnesium carbonate that would be formed if soda ash was used, and therefore caustic soda is better than soda ash for treating water containing magnesium sulphate. A combination of both soda ash and caustic soda is most effective if there are both magnesium and calcium sulphate present.

The amount of soda ash or caustic soda required would depend on the amount of sulphates in the water. An analysis of the water will show how much is needed. Chlorides and nitrates can be removed in somewhat the same manner as the sulphates.

"Zeolites" are also used sometimes in treating water. A zeolite is a substance found in nature and contains aluminum, silica and sodium. It is also manufactured commercially and used quite extensively. The action of a zeolite is to exchange the calcium or magnesium in the bicarbonates or sulphates for the sodium. The calcium or magnesium bicarbonates then become sodium bicarbonates and the calcium or magnesium sulphates become sodium sulphates. Both of these sodium compounds are highly soluble and up to a certain degree will give no trouble. Beyond a certain point foaming is likely to occur, and therefore, where the percentage of bicarbonates is high, a combination treatment is frequently employed.

The zeolite, after it has given up all its sodium in exchange for the calcium and magnesium, can be restored with a solution of common salt, which is sodium chloride (NaCl). In this operation a second change takes place whereby the sodium takes the place of the calcium and magnesium. The zeolite is then ready to be used again. This process can be repeated indefinitely.

This outline of exterior treatment is very brief, but the subject has already been treated more extensively in *Power*, so we may pass on to the subject of interior treatment.

Principles of Interior Treatment

As soon as water is fed into a boiler, the heat breaks up the bicarbonates of lime and magnesia and forms the carbonates of lime and magnesia. The carbonates are insoluble and, if given a chance, will be deposited as a sludge that can be blown off. If the boiler is in continuous service, a considerable amount of the carbonates will adhere to the tubes, shell plates and heads of the boiler and form scale, particularly if there are other substances with which it may combine. If a boiler can be taken out of service part of the day, the deposits have an opportunity to settle on the bottom of the boiler, and can be blown off shortly after shutting down.[2]

The carbon-dioxide gas (CO_2), which is liberated when the heat breaks up the bicarbonates, is carried out of the boiler with the steam. Magnesium carbonate at high temperatures may be converted into magnesium hydroxide, which is also insoluble. There are no chemicals that can be used to advantage in a boiler in the treatment of bicarbonates, since the heat produces the same effect as any chemical. Where the quantity of bicarbonates is excessive, the exterior treatment should be resorted to.

The sulphates of calcium or magnesium can be treated effectively in a boiler with soda ash. If an analysis has been made of the water, the amount of soda ash necessary can be calculated. It takes about 1.8 oz. of soda ash for each 1,000 gal. of water if there is one grain per gallon of calcium sulphate. Multiplying the number of grains per gallon by 1.8 will give the number of ounces of soda ash needed for each 1,000 gal. of water.

Likewise it takes about 2 oz. of soda ash per grain of magnesium sulphate per gallon, for each 1,000 gal. of water used.

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[2]Some claim that the best time to blow off is just before putting a boiler into service again, but this gives the deposits an opportunity to adhere to the bottom of the boiler and become "scale." If the boiler is blown off shortly after shutting down, allowing time for them to settle, the deposits are still in a flocculent condition and will more readily move to the blow-off opening.

If a complete analysis of the water has not been made, the exact amount of soda ash needed cannot be determined, but the approximate quantity can be found by experiment. Start by using only a small amount, say about one pound per day for each boiler, and observe the results. If it is found that the scale ceases to form, the amount of soda ash can be reduced to a point where it is found sufficient to prevent scale formation. If scale continues to form, it is an indication that not enough soda ash is being used and the amount should be increased and the results again observed. If the water is likely to vary, as for example in the case of shallow well water, the amount of soda ash will also have to be adjusted.

Use of Soda Ash in Boilers

If a large quantity of soda ash has to be used, it is likely to cause foaming. If the quantity of sulphates is high, it will require so much soda ash that foaming will result. When this condition develops, no further attempt at interior treatment should be made. Have an analysis made of the water, to determine what exterior treatment is needed.

Sometimes caustic soda is used in the interior treatment. Its action is to convert calcium sulphate into calcium hydroxide and sodium sulphate, and magnesium sulphate into magnesium hydroxide and sodium sulphate respectively. The magnesium hydroxide formed is insoluble and would be deposited. The calcium hydroxide and sodium sulphate formed are highly soluble and cause no trouble as long as the boiler is blown off regularly. Caustic potash is also sometimes used, and its action is practically the same as that of caustic soda.

However, unless the caustics are used in a carefully regulated way and by responsible persons familiar with their properties, it is better to use soda ash for if used to excess they are likely to injure the boiler and may cause trouble with joints and packings. They are also likely to cause personal injuries, by burning, unless handled carefully.

It is claimed by some authorities that caustic soda has the effect of making boiler plates brittle and causes cracks around seams and rivet holes below the water line, this phenomenon being termed "caustic embrittlement." It is also claimed that sodium carbonate in excess breaks down and forms caustic soda and that this may bring about the same phenomenon, even though no caustic soda has been used in treating the water. The theory is that caustic soda of sufficient strength attacks iron and liberates free hydrogen, the latter entering into the texture of the metal and affecting its qualities. According to this theory, therefore, it is even important to limit the amount of soda ash used so that there will not be a large excess.

In view of the foregoing it would appear that soda ash accomplishes just as much as caustic soda or caustic potash and is not as questionable in its qualities, and it should therefore be preferred where the interior treatment has to be used for sulphates.

In a good many cases the use of a little soda ash, regular blowing down (2 in. daily) and frequent washing out (at least once a month) will keep a boiler in satisfactory condition so far as scale formation is concerned. Where a boiler is in continuous service for long periods, an increase in the amount of soda ash and more blowing down may answer the purpose. The worst cases of scale are often due to an utter disregard of these primary rules.

Before any treatment is started in a boiler, all old scale should be removed. This can be done by closing the stop valve, filling the boiler with water, putting in about one pound of soda ash for each twenty square feet of heating surface and boiling slowly at a pressure of five to ten pounds for a week or ten days. The boiler should be blown down about two inches each day, until the water reaches the bottom of the glass. Then empty the boiler and wash it out thoroughly. If any scale remains adhering to the boiler parts, it may be removed by mechanical means, otherwise the treatment should be repeated.

In using soda ash it may be dissolved in water and fed into the boiler continuously and automatically by some sight-feed arrangement at the suction end of the feed pump or it may be put in the hotwell. The apparatus can be properly adjusted after a little experimenting. To dissolve one pound of soda ash about 4½ gal. of water is needed. During a trial treatment the boiler should be opened up often in order to observe the results of the treatment.

The amount of blowing-off necessary depends on the quality of the water and can be determined only by careful experimenting, but the blowing-off should in any case be done regularly and at the most effective time.

Referring to a very special case, it is quite common in water works to use alum to purify the water for drinking purposes. The action of alum, which is technically known as aluminum sulphate, is to convert the carbonates to sulphates. In other words, it removes the temporary hardness but increases the permanent hardness. As sulphates are more objectionable than carbonates, it is apparent that, as a general rule, alum-treated water should not be used in boilers.

At first sight it seems rather peculiar that actual pipe sizes differ so much from the nominal sizes, particularly in the smaller pipes. A one-inch standard pipe has an internal diameter of 1.049 in. and an ⅛-in. pipe has an internal diameter of 0.269 in., more than double the nominal size. Why should not the internal diameters be the same as the nominal sizes within reasonable manufacturing limits? The answer is found in the necessity of standardizing the outside diameters to permit of interchangeability. Repairs and additions to piping may be made long after installation. To avoid the necessity of carrying special fittings for connecting old piping to new, it is essential that all piping of a given nominal size have the same outside diameter and the same size and style of threads. In the early days when piping was first standardized, manufacturing methods were crude. The internal diameters were made the same as the nominal size, and the thickness of wall then considered necessary fixed the outside diameter. Later manufacturing improvements made it desirable to use a thinner wall for standard pipe. Since the outside diameter, once fixed, could not be economically changed, the only alternative was to increase the inside diameters.

Oil deposits or sludge in steam turbines are yellowish, gray or black. The former is usually soft and easy to remove, heavier than water, cannot be dissolved by kerosene and is most often found in the lower piping or reservoir. The black deposits often occur around bearings and hot parts and sometimes stick tightly and are quite hard.

Stokes Anthracite Culm and Gashouse Tar

BY JOSEPH HARRINGTON*

A MIXTURE of anthracite dust and liquid tar from gas producers is burned successfully on forced-draft chain-grate stokers with no modification of the furnaces at the plant of the Consolidated Gas & Electric Co., at Long Branch, N. J. Ratings up to 225 per cent of normal have been carried. In this way a pile of material formerly considered waste was converted into a valuable fuel.

PRESENT-DAY conditions demand the utilization of fuels that are more or less off-grade, not only for reasons of cost, but because clean, high-grade coal is becoming daily more scarce. With freight rates and labor conditions as they are now, it is imperatively demanded that fuel costs be cut as much as possible. For a long time I have laid special stress on the economic necessity of utilizing the low-grade fuels of the country, but it has been a problem not easy of solution, and one involving a great deal of experimentation, often with expensive and disappointing results. It is my belief, however, that the low-grade fuels of the country can be stoked successfully and the heat values resident therein can be extracted economically and turned to good use. Thousands, if not millions, of tons of coal lies dormant in the mines and dumps of the country, which ought to be producing its quota of useful power, and the subject becomes, therefore, of far more than mere academic interest.

Not long since, Mr. Cutcheon, the general manager of the Consolidated Gas & Electric Co., of Long Branch, N. J., had a fuel-burning problem on his hands that proved to be of great interest. The power plant of this concern consists of two 5,000-sq.ft. Stirling boilers with a furnace 11 ft. 9 in. wide. Harrington forced-draft stokers 11 ft. wide and 15 ft. long are installed, and the whole is served by a chimney 175 ft. high. It is a new plant designed by the engineering department of the American Light & Traction Co., of which W. C. Beckjord is chief engineer; but it was never expected that anything other than Eastern bituminous or anthracite steam coal would be burned.

It so happened, however, that this company had been using anthracite coal in certain gas producers, and there had accumulated a considerable tonnage of coal too fine to be used in the producers, which had been thrown to one side until quite a pile had accumulated. This coal was fine in size and exceedingly dusty when dry. It was not possible to hand-fire it, because of inadequate draft and furnace arrangements. It was, therefore, considered practically a waste product.

The gas department of the company produces daily a certain amount of a liquid tar, which is not in sufficient quantity to warrant rigging up a special furnace and boiler for, but which, having considerable heat value, they did not desire to waste. Also, to utilize it efficiently, a large tank would need to be erected and suitable pumping and other handling facilities provided, all of which would have meant considerable expense and ground space, as well as fire hazard and other considerations. Accordingly it was considered more or less waste and was thrown on top of the pile of anthracite dust. In the course of time the entire pile became saturated and the tar began to run out at the bottom. It was at this time that the whole thing began to assume the aspect of a nuisance, and the writer appeared on the scene to see if it were possible to utilize this combination fuel in the new boiler plant without modification of the furnace or stoking equipment.

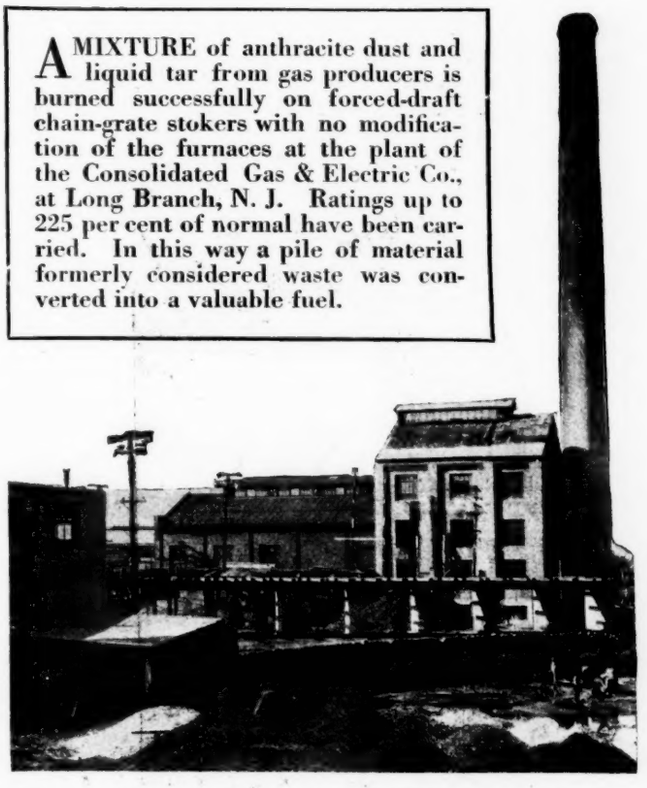

FIG. 1—LONG BRANCH PLANT OF CONSOLIDATED GAS & ELECTRIC CO.

As the material was brought into the boiler room, it was dumped off the end of the belt conveyor, falling loosely in a pile on the floor in front of the stokers. it had all the appearance of a load of asphalt and sand, such as is used for the surfacing of macadam roadways. Stepping on this material would pack it into a soggy mass, just the same as the asphalt material is consolidated under the wheels of a steam roller. It was necessary, therefore, to avoid any such consolidation, and under instructions it was shoveled into the stoker hopper in such a manner that it fell loosely therein. In order not to compress this fuel as it passed onto the grate, the gate was raised to a height of 7 in. above the grate surface, and the stoker speed was cut down to a degree that insured the complete burning out of this rather heavy fuel bed within the proper limits.

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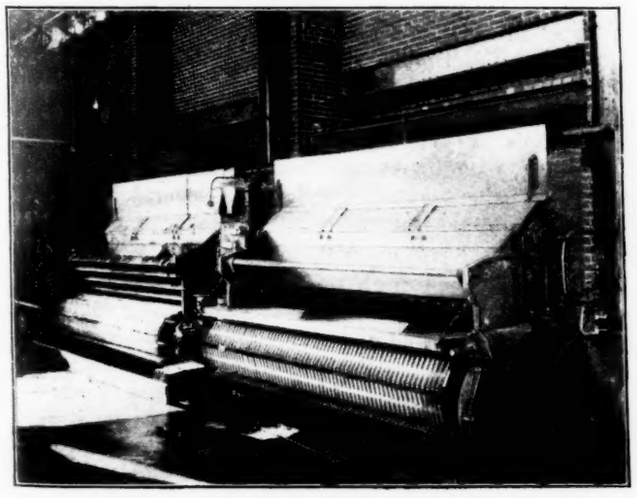


FIG. 2—FRONT VIEW OF STOKER INSTALLATION

Ready surface ignition was anticipated, but what would happen thereafter could not be predicted. It was feared that the tar would be driven down by the heat of the fire into a more liquid state and render the lower layers of the fuel bed so dense that no air could pass up through. This proved, however, to be wrong. A strong pressure was maintained in the front compartment for the purpose of overcoming any such tendency, and with apparent success, since the mixture ignited with readiness right up to the gate and combustion proceeded with great intensity until the fuel

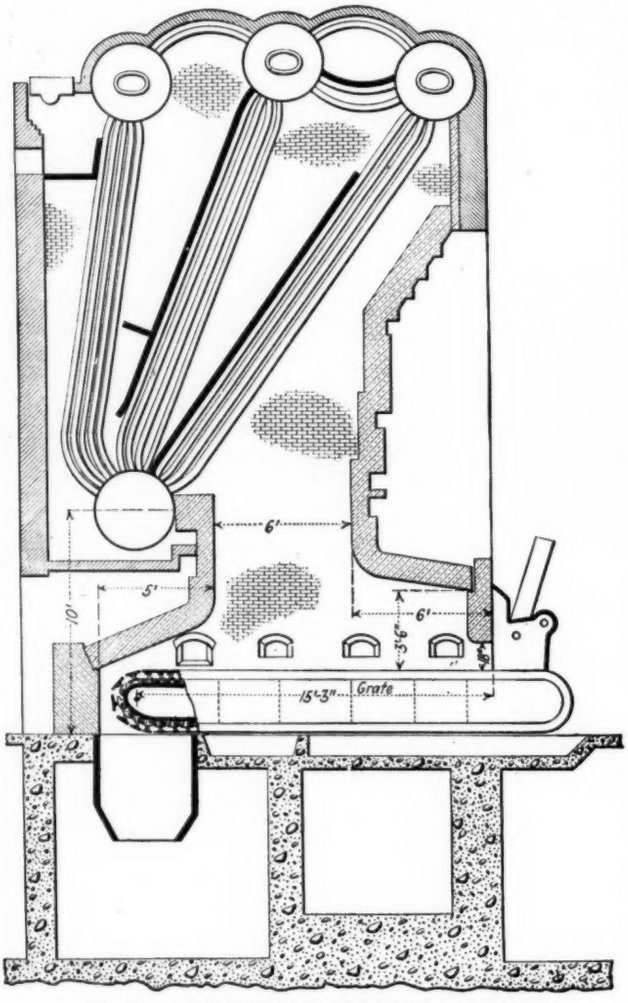


FIG. 3—SECTIONAL ELEVATION THROUGH BOILER SETTING

had progressed approximately one-half the length of the grate. At this point apparently all the tar was burned out, leaving a porous bed of fine anthracite of uniform texture which burned much as any anthracite fire burns. In other words, there were short tongues of flame shooting up through the fuel, a volume of transparent monoxide gas at the surface burning to a complete CO_2 product in the upper part of the furnace. Smokeless combustion resulted, and in due course the anthracite culm had all burned down to a perfect ash.

Draft in the furnace was maintained as usual at a point near neutrality. The pressures in the stoker compartments, of which, in this instance, there are four, were maintained much as usual with anthracite fuel, except that care was taken to keep the front compartment under full pressure, which, in this instance, averaged about two inches. The second compartment, where the most active combustion took place, was maintained under high pressure, although of slightly less degree, and the third compartment stepped down to perhaps one-half inch. The fourth compartment was cut down sometimes to zero, and sometimes to one-quarter inch, according to the appearance or disappearance of fuel over the compartment.

It was particularly gratifying that loads up to 225 per cent of rating were carried, it being possible even with this fuel to carry the load over the peak with a fair margin to spare. In general, it may be stated that the fuel was quite satisfactory, and if it had been used any length of time, would have been considered dependable. The novelty of the situation the first day naturally called for a boiler in reserve, but it was found that this was not needed, and if a sufficient quantity of combination fuel had been available, it could have been used with safety, especially in the season of the year not requiring excessive peaks. On the whole the experiment was of great novelty and interest and a source of considerable satisfaction to the owners, inasmuch as it converted a pile of virtually waste material into just that much valuable fuel.

A word of comment on the furnace design may be of interest. Fig. 3 will show that there is nothing extreme about the design, and as previously indicated, it was not built with the expectation of burning unusual fuel. The combination fuel described, however, could scarcely be classed as anthracite in its furnace action, the combustible tar making the matter of ignition a simple one. It is more than likely that any well-designed furnace would handle this fuel so far as ignition is concerned.

The total furnace volume figures out 7.7 cu.ft. per square foot of grate area and 0.25 cu.ft. per sq.ft. of heating surface. With bituminous coal this furnace is smokeless and admits of ratings up to 250 per cent without destructive temperatures.

A cylindrical tank under internal pressure might be imagined as bursting either with a lengthwise split or with a crack running around the shell. Where the ends are properly bulged or stayed, the tank will burst along a lengthwise joint. This joint is under tension due to the internal pressure. To figure the amount of this tension for any portion of the length of the shell, consider the shell split lengthwise and one half pushed out like a piston. The force on a piston is figured from the projected area. If the tank is 20 in. in diameter, the projected area for each inch of length is 20 sq.in. With an internal pressure of 200 lb per sq.in. the total force on this section is $20 \times 200 = 4{,}000$ lb. Since half of this is carried by each side, the total tension per running inch along any lengthwise joint is $\frac{1}{2} \times 4{,}000 = 2{,}000$ lb. For safety the thickness of the metal and the size and arrangement of rivets must be such that the breaking tension of the joint is several times this amount per running inch.

An unnecessarily high temperature in the uptake on smoke flue of a boiler usually indicates poor economy, because it shows that a considerable quantity of heat that should be absorbed by the boiler is being discharged to the stack wastefully. A low temperature, however, does not always indicate good economy because it may be due to leakage of air through the setting or through some of its connections or to imperfect combustion in the furnace.

Non-Condensing Unaflow Engines

By Horace G. Cooke

In the preface of his treatise, "The Una-Flow Steam Engine," Prof. J. Stumpf declares that his research in the steam-engine field had for its object the attainment of the minimum total of all the seven different losses of the steam engine, as well as the utmost simplicity and reliability of operation.

That he fully attained this object by the correct application of the unaflow principle in condensing engines he demonstrated both by scientific experiments and by the results obtained by actual engines. That he only partly succeeded in reducing the losses in non-condensing engines he frankly admits.

Sacrifice of Unaflow Principle

Professor Stumpf's failure to secure the same degree of success in non-condensing as in condensing engines was due to the fact that he did not discover any means of getting rid of the steam trapped in the cylinder by the piston covering the exhaust ports excepting by some method that sacrificed some of the economies of the unaflow principle.

The full attainment of the object which Professor Stumpf realized in condensing engines is fully comprehended in the phrase "una-directional flow," which is essential to the highest economy and is impossible in either a condensing or non-condensing engine without the retention of the very valuable series arrangement of live-steam space, inlet valve, piston and exhaust. Professor Stumpf lays more emphasis on this very valuable series arrangement than on anything else in his entire treatise on the subject. In other words, a true unaflow non-condensing engine is one in which the live steam enters the end of the cylinder, takes heat during expansion from the steam-jacketed heads and thereby forces the moisture due to converting heat into work to the cold end of the cylinder and leaves through the central exhaust ports.

Manufacturers in this country have offered non-condensing engines which in design and operation are more counterflow than unaflow, with the result that quite a number of interested laymen, some operating engineers, and a fortunately small number of consulting engineers have received erroneous impressions of what a true unaflow non-condensing engine is.

What Is a Unaflow Engine?

One of the erroneous impressions that exist is that an engine with central exhaust ports, long piston, poppet steam valves, steam-jacketed heads and increased cylinder clearance is a true unaflow engine.

While such an engine preserves in its design the series arrangement, it cannot possibly give the fullest unaflow economies for the very evident reason that one great advantage gained by the unaflow principle is from increased expansions, which is impossible in this design. The greatly increased cylinder clearance gives too large a cutoff volume to get any better expansion than in a counterflow engine. Professor Stumpf says of this type in comparison with the use of auxiliary exhaust valves: "The general adoption of the additional clearance space despite this considerable loss in steam consumption is due, firstly, to its simplicity, and secondly, to qualities which tend partly to counteract this heavy loss. The effect on the over-all economy is negligible if an engine operates with additional clearance only for several days or hours during the course of a year." In other words, this is all right in a condensing engine which operates for brief periods non-condensing, but is not suitable for continuous non-condensing operation.

A second erroneous belief held by many is that all unaflow engines must have poppet valves. This erroneous idea doubtless comes from such statements as "Any unaflow engine must have steamtight poppet valves." It is admitted that in any unaflow poppet-valve engine the poppet valves must be steamtight if the engine is to be of any service. But that poppet valves are essential to unaflow engines is not a fact. A unaflow engine may have Corliss, piston, poppet or any other design of valve. In fact, the only non-condensing engine described by Professor Stumpf in his treatise of which he says, "The unaflow principle is fully adhered to," does not have poppet valves, but instead, a single steam-packed piston valve.

Still another erroneous impression is that a unaflow engine must have auxiliary exhaust valves. This is not only not so, but on the contrary to the extent to which so-called auxiliary exhaust valves are employed, to that extent the engine is counterflow. Neither does changing the location of the so-called auxiliary exhaust valves, moving them 25 to 30 per cent from the end of the cylinder, make a unaflow out of partial counterflow engine.

The Inventor's Opinion of Auxiliary Exhaust Valves

Professor Stumpf says that auxiliary exhaust valves are a detriment to the unaflow engine. He asserts that they increase the clearance space and the harmful surfaces as well as the possibility of leakage, and sacrifice the very valuable series arrangement of live-steam space, inlet valve, piston and exhaust. For 1 per cent increase in clearance volume an additional steam consumption of 0.26 lb. per indicated horsepower may be expected, superheated steam and atmospheric exhaust being assumed.

Auxiliary exhaust valves are no essential part of a unaflow engine and a decided detriment thereto, not only in making it impossible to realize completely the unaflow principle, but they add to the mechanically operating parts.

There is, however, one engine described by Professor Stumpf that attains the same relative degree of economy in non-condensing operation that he attained in condensing engines. This engine is one in which the unaflow principle is correctly and effectively applied by the introduction of the dual clearance principle whereby at some point in the compression stroke the steam being compressed in the auxiliary clearance space is transferred to the other end of the cylinder where it mixes with the expanding steam.

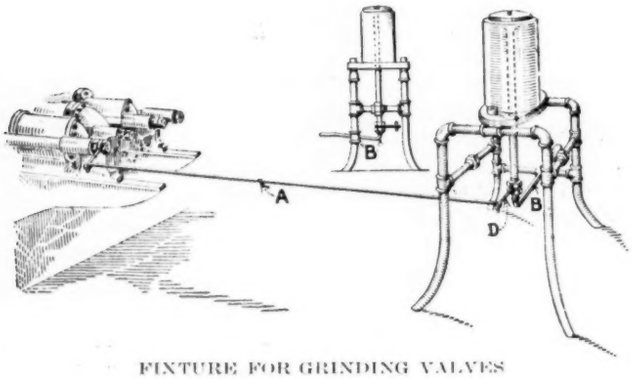
This engine, Professor Stumpf says, is of especial interest as in it the unaflow principle is fully adhered to since the exhaust steam leaves only through the central exhaust ports. The effect of this dual clearance is to raise the expansion line and lower the compression line. Consequently, the mean effective pressure, output and uniformity of speed are somewhat increased and the necessary flywheel weight is decreased.

Care of Oil Engine Valves

By J. E. Hauser

The care of valves of Diesel and other internal-combustion engines calls for a little ingenuity and common sense, for the condition of the valves is a matter of vital importance if the proper combustion of fuel and maximum efficiency are to be obtained. The condition of such a valve is, as a rule, determined by the sealing quality of the seats, there being several known methods of determining this. Nearly everyone has his own method, which is probably as truthful as the other fellow's.

Where the valve seat is integral with the cylinder head the proper grinding of the valve is all that is needed. This, however, does not always apply where a valve cage is employed, unless a little precaution is used. Valves of the latter type are extensively used



FIXTURE FOR GRINDING VALVES

by the majority of engine builders, especially of the large units, and are also favored by engineers by reason of the convenience of handling. I have observed many cases where, after a good grinding job was done and the valve replaced in engine head, inspection disclosed the fact that the valve seat had a clearance of 0.017, caused by deformation of the valve cage seat. These seats will always be deformed unless a little judgment is used in drawing up the nuts of the cage studs. Some engineers avoid this deformation by removing the cylinder head and, with valve cages intact, grind in the valves as though they were integral with the head casting. This is a certain method, also a laborious one and uncalled for if one exercises a little care. That the size of the studs was determined to withstand the stresses set up by the high cylinder pressure and not to bear all the strain that can be applied by two or three men at the end of a six-foot pipe wrench should be understood by all.

Some engineers contend that one or the other gasket will blow or leak if the cages are not drawn down in this manner. Valve cages usually have two joints, the water and fire joint; obviously, the fire joint, being subject to the high cylinder pressure, should be the one to be guarded against blowing. Since heavy packing or gasket used on the water joint offers too great a resistance to the tightening up of the fire joint, the engineer should see that the gasket is of the correct thickness. It is also necessary to have joints absolutely clean, so that no grit, scale or carbon can obstruct the true facing of the joints. With these suggestions followed and with the valve-cage bolts drawn up tight in a reasonable way, satisfactory results will be obtained.

Some still use the old hand method of grinding valves, while others employ mechanical means, for grinding a valve by hand requires much hard labor. A simple and practicable arrangement is shown in the sketch. It consists of about seven feet of ½-in. round iron for the driving rod and a stand for holding the valve, which may be made of 1-in. pipe as shown or built of wood.

The valve cage is placed on the stand, two pipe nipples passing through the cage-bolt holes. The short iron lever *D* is slipped over the valve stem and clamped by the nuts. The rod *A* is shown attached to the rear crosshead of a 5x24-in. Deane oil-pipe-line pump, but may be attached to any object having a reciprocating motion. The speed should not be over 50 strokes a minute. The valve is given a rotating motion which soon grinds its seat to a better finish than is usual in hand grinding. It is good practice to change the position of the valve in relation to the cage. This is brought about by loosening the locknut and shifting *D* to a different position on the stem. To apply grinding compound, the valve is lifted by the lever *B* without interfering with the motion of *D*.

Checking Up Boiler Efficiency

The final check on any method of operation is a boiler test, but analysis of flue gas for carbon dioxide and carbon monoxide, together with measurement of the flue temperature, shows the size of the principal loss. If this loss is kept low, and it is evident by inspection of the ashes that little combustible is being lost through the grate, the efficiency must be good, provided there are no serious steam or blowdown losses.

If, for a given load and a given percentage of carbon dioxide, the flue temperature is higher than normal, it simply means that the boiler is not absorbing a fair share of the heat generated. The only cure for this is to keep the tubes clean inside and out.

To make a complete and accurate boiler test with all the refinements is an expensive and difficult task, but it is a simple matter to make a rough test, provided there is some means of measuring the coal fired and the steam produced. The coal fired may be weighed on platform scales, while the steam can be measured directly by a steam meter in a rough test, or more accurately by weighing or metering the feed water and then subtracting the water and steam that are lost by blowdown or otherwise.

The deposits on the inside surfaces of condenser tubes must be removed from time to time as the vacuum shows signs of impairment from this cause and as operating conditions permit. One of the following methods may be used: If the trouble is caused chiefly by débris such as leaves, straw or small fish, etc., clogging the openings of the tubes, it may often be removed very quickly by draining the water-boxes through a 6-in. connection at the bottom; soft deposits of mud or silt may be washed out by means of a high-pressure stream of water directed through each tube by means of a nozzle. A method requiring more time, but which is more effective, is that of shooting leather disks (with a nail through the center of each to guide its movement) through the tubes by compressed air. To save time, the disks may be shot through one pass by one gang of men and through another pass by another gang.

EDITORIALS

F. R. LOW, EDITOR

New York's Water Power

ASIDE from some preliminary investigations, till quite recently little serious thought has been given to hydro-electric power as a factor in the power supply of the Metropolitan District embracing New York City and adjacent localities, including part of New Jersey. This section is now supplied wholly by steam power, but the rapid growth in load, increasing cost of coal and improvements in long-distance transmission have combined to bring the subject of hydro power to the front at this time.

The possible sources of supply are the St. Lawrence, additional diversion at Niagara, the Hudson River watershed, the Delaware and the Susquehanna—some adapted to the supply of base-load power and the others to peak-load power. These sources, according to estimates of the Superpower Survey, would be able to supply about one-third the Metropolitan load by 1930; beyond that the ratio of hydro to steam power would decrease if the projected load curves are correct.

The problem is largely one of ability to deliver reliable hydro power to New York City at a price that can compete with steam power, all things considered. On this point there is a division of opinion which for the present must continue to exist in view of the limited information. In any event, the more unified the system the greater the reliability, necessitating less reserve equipment and making possible a correspondingly reduced cost of power delivered at the switchboard.

Coincident with a revival of interest on the part of engineers comes the legislation urged by Governor Smith of New York, providing for state development on a huge scale. The Rabenold-Hackenburg bill, just introduced, deals only with the St. Lawrence and Niagara projects the power from which it is proposed to send over publicly owned or rented high-tension lines to the various municipalities of the state. The bill would place full jurisdiction in the hands of the state engineer, although the other undeveloped water powers would remain under the present state water power commission. On the theory of state's rights, New York's chief executive would confine utilization of the hydro power to the state and even challenges the authority of the Federal Power Commission in the cases of Niagara and the St. Lawrence.

Because of diversity of load demands, irregularity of the flow on certain rivers and lack of storage facilities on others, maximum utilization that will benefit the greatest number can be had only through an interconnected system transcending state boundaries. Whether this will mean the transmission of large blocks of power over great distances or merely the tying in of all existing sources, supplementing one another, is a problem to be worked out upon its merits. It is important, however, that this be solved along engineering rather than political lines, or to put it in another way, those charged with administrating public affairs must be taught to think along engineering lines in the matter of water-power developments. Happily, this is the case in Pennsylvania, where Governor Pinchot has the vision of a nation-wide interlocking power system in which the burning of coal and the flow of water contribute their energy to a reservoir for the connection of supply to farms and railroads.

Much will depend upon the decision in the case now pending before the Supreme Court, in which New York State is challenging the authority of the Federal Power Commission.

Insuring Crankshafts of Internal-Combustion Engines

THERE has been at various times more or less discussion concerning crankshaft failures in internal-combustion engines. The idea is often advanced that as compression pressures are raised, the likelihood of such failures increases in like ratio. The result of this reasoning is the refusal, or at least disinclination, of one or more of the casualty companies to insure Diesel crankshafts against failure.

It would seem that the objection is based on the matter of high compression pressures, since policies are issued on semi-Diesel or on any internal-combustion engine where the fuel ignition is not brought about solely by the heat of compression. While in no way desiring to detract from the merits of other engines, attention is called to the lack of logic in the proposition. In the Diesel engine the fuel is not introduced until practically dead center. No preignition can occur unless there is a misadjustment of the working parts. Fuel ignition is under positive control unless the fuel valve is wilfully set incorrectly.

On the other hand, many types of engines receive the fuel into the working cylinder during the compression stroke. It is then impossible to control the time of ignition with accuracy, even though the engine mechanically be in excellent condition. Preignition is more likely to occur in such engines.

If engineers who are familiar with internal-combustion engines agreed that such crankshaft failures as have occurred were the result of preignition, engines in which no fuel enters the cylinder until the compression stroke is completed would be less liable to such damage than engines where an air-fuel mixture is in the cylinder during all or part of the compression stroke. From this viewpoint, the controlled-combustion engine would then be the better risk.

That the majority of crankshaft failures in internal-combustion engines are traceable to preignition or any cylinder conditions is not generally conceded. Examination of the engine after an accident will in most cases show that the shaft bearings were not in alignment and that the shaft fracture was due to misalignment of the bearings. Alignment is a matter that is under the control of the engineer. The question of the advisability of insuring a crankshaft should be based not upon engine type, but upon operator type.

Saving Money in Repairs

MUCH is written of the power-plant economies in fuel, methods of operation, labor, coal and ash handling, etc., but maintenance and repairs are usually far in the background of public attention, although the operating engineer usually spends more time, thought and worry on these latter items than any two of the former.

In the last analysis repair work appears to be of prime importance since it not only may affect the various desired economies, but also may endanger the reliability of a plant and perhaps, in consequence, that of an entire system.

Owing to the intensive study that this subject necessarily receives where service reliability is the most important product, the routine of maintenance and inspection holds such matters in check. Analysis of physical conditions and symptoms of possible or authenticated trouble by experienced men may form the basis of an apparently never ending campaign to keep things going well. The lesson of the large plant, which may be applied with profit to the smaller one, is to meet trouble half way or preferably to remove the causes tending to produce it rather than await the inevitable breakdown or power interruption.

There are, however, two factors in the warfare against repairs, which are often lost sight of by the management. The modern power-house unit, designed for high economy with least possible first cost, is inclined to be a highly organized sensitive device. It depends on adjustments or special construction, which calls for attention, care and accuracy primarily when installing, and secondarily in operating. The first requisite is therefore careful checking by the purchaser of all steps made by the manufacturer when installing power equipment. Details that would appear insignificant to a workman employed by an outside concern may, if neglected, result in tying up a large plant or shutting down a system. A gasket omitted from a vacuum line, rubbish from welding carelessly left in the steam passages of the boiler or a supposedly flexible steam connection which is erroneously made rigid may cause expense and embarrassment at an unexpected time, which was not reckoned with in the original estimated costs.

The second factor is the matter of conveniences for repair work. The practically trained man may value a certain wrench at about ten to one hundred times as much as a technical graduate. The wrench may seldom be used, yet when repair or dismantling becomes necessary, this tool might save a day's time otherwise required for making up a special implement for that purpose.

When a large unit is being installed, sometimes costing in the neighborhood of half a million dollars, it is not uncommon to see the complete set of wrenches, spanners and trams which accompany the unit gradually disappear, until scarcely any of the original collection remains when the machine is finally accepted by the purchaser. A wise executive, knowing the value not only of such tools, but essentially that of a complete set, could often save money by obtaining an authentic list of such material and then ordering a double set to be kept completely up to date in the plant.

Occasionally one sees a station where wrenches, hammers and such accessories are carefully hung up in specially prepared places, after the manner of the familiar wrench board of the small-plant engineer. Locations for keeping bulky apparatus, such as wire rope slings, hydraulic jacks or lifting spreaders may have received attention from the designing engineer. On comparing with a plant where considerations of good looks or possible beauty ruled against such thoughtful conveniences, most experienced men would favor the former type of installation.

Enlargement of Production by Mechanical Development

THE American representatives at the Rome meeting of the International Chamber of Commerce presented a resolution defining some of the fundamental considerations that must be observed if sound settlement of world economic problems is to be accomplished. This resolution gives first place to the need for "enlargement of production by every invention and mechanical device which offers economy of production."

This proposal, among others, proved so sound and so convincing that it was adopted by the International Chamber as a fundamental of unquestioned importance. America has already practiced this economic doctrine widely, but even in the United States there is large opportunity for further application of the principle.

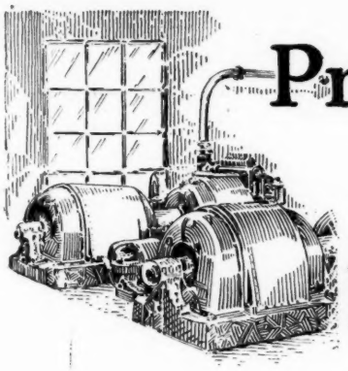
It is a well-recognized fact that there are always more consumers than there are producers. It is inevitable, therefore, that advances shall be made by enabling the producer to make more product in a given time than heretofore if consumers are to consume more of the product. In other words, the standard of living of the community is determined essentially by the ability of the individual producer measured in output per hour or per day. Anything that will increase the individual's capacity for production contributes to the general welfare to just that extent.

The greatest single factor in enlargement of the powers of the individual worker is the supply of machine power for every operation that can be mechanicalized. The mechanicalization of industry is, indeed, a direct measure of the standard of productivity and that of the standard of living of the community as a whole.

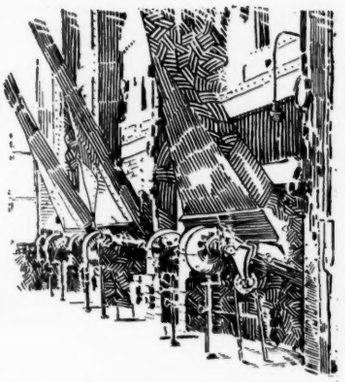
Elimination of artificial restrictions on the work to be done by the individual, stimulation of individual effort by special remuneration to unusually skilled workers, adoption of sound governmental policies with respect to industry and its taxes, and the clear recognition of the rights of business—these are all set forth in this general resolution. They all are important, but none of them is of greater importance than that one which is placed first—"the enlargement of production by every invention and mechanical device which offers economy of production."

This one is perhaps even more fundamental than any other principle stated. It is to be hoped that the principle will be still more widely recognized and applied in this country than ever before, for increases in horsepower are far more profitable to industry than the corresponding increases in man power. Let us give every encouragement to the mechanicalization of industry, strengthening the arm of the worker and, what is even more important, using his directing brain to the maximum, not alone the strength of his arm.

A subscriber who has bound his copies for years, lacks the indexes for both volumes of the year 1915. Can anybody help him out?



Practical Ideas *from* Practical Men



Coal Practices

I am going to give you some inside coal facts and show you how the coal dealer is putting it over.

In the years from 1903 to 1906 I was trying to find the most economical mixture to burn in making steam for this plant, and was never able to beat a mixture of two parts of soft to one of hard coal.

In 1903 soft coal cost $3.85 and hard $2.47 per ton of 2,000 lb., making the two-to-one mixture cost $3.39 per ton.

During the war the Government advised all steam plants to use a mixture of two of soft coal to one of hard-coal screenings, or buckwheat coal, and almost every cotton mill in Fall River was using that mixture during the coal shortage. After the war was over, a great many of the mills went back to straight soft coal, when soft coal was selling at $8 and screenings at about $3.50 per ton.

All yard waste is now screened over, and every particle of pea and rice sizes taken out and sold at $12 per ton, and every truck load of six tons of supposed soft coal sold to the mills contains from 25 to 30 per cent of nothing but the dust of hard coal, and they are getting $9 per ton for the mixture.

I accused the agent of the coal company of these tricks, and he said that the coal dealer was not doing any more profiteering than the cotton manufacturer. That is all the satisfaction I got. His company divided a 1,200 per cent stock dividend about six weeks ago.

Fall River, Mass. M. H. HARRINGTON.

Thought the Chief Had a Soft Snap

Several years ago there was employed in a large Eastern power plant a young man of considerable ambition and with more than the average amount of intelligence. He held a subordinate position, with no other responsibility than to do each day's work as it was presented. This man was offered, and accepted, a position as chief in a small station in another city. He was successful, or as the boys express it, "he made good." Knowing the man as I did, I felt sure that he would make good. About a year after taking the position his former chief met the man and asked him how he was getting along. He replied:

Oh, I think I am succeeding all right. The management tell me that I am, and if they are satisfied I surely ought to be. But say, I have learned one important thing, and that is that a man's opinion of a situation depends a great deal upon his point of view. When I worked for you, I often envied you because you had no hard or dirty labor to do. It seemed to me that all you did was to walk around the station and give orders, while I had to work hard for far less money. When I finished my work at night, I went home and forgot all about the station and my job. Not a thought did I give to them until the next morning, and I supposed you did the same.

Now I know different. Do you think that I can forget that plant of mine when I go home at night? No more than can you yours. At the movies, at the dining table, in the wakeful hours of the night, its troubles and its problems are with me. I can never get completely away from it. I realize now the burden that you were carrying—that you are now carrying, and it is a hundred times greater than mine in magnitude. Mine is great enough, but what must yours be!

Nothing can be more true than the foregoing and it applies to every station great or small. Many an intricate problem of management, of upkeep and of economy is solved by the chief, not during his working hours, but in those so-called hours of leisure when he is supposed to be enjoying himself or obtaining the necessary sleep. Let no man think the chief has "a soft snap" for some day his point of view may be changed, he may alter his opinion as did the man in the case just cited. A. J. CALHOUN.

Lawrence, Mass.

Motorizing a Three-Phase 600-Kva. Alternating-Current, Engine-Driven Generator

In running a series of tests on a condensing unaflow engine it became necessary to test the surface condenser for leakage. There was a controversy as to the leakage obtained on a previous test; so to make certain that no steam was leaking through from the engine to the condenser, it was desired to drive the wet vacuum pump while steam was shut off from the engine. But the air pump was belt-driven from the main engine shaft, and it was found impractical to set a motor to drive this belt.

It was finally realized that it would be all right to motorize the alternator and run the test in that manner, with the engine throttle closed and the steam pipe between the throttle and the cylinder opened by a valve to atmosphere.

The load was taken off the engine, but the switches were all left as they were, when the throttle was closed and the auxiliary exhaust valves were opened to relieve the excessive compression of the air in the cylinder. The alternator kept on going as smoothly as anything, running as a synchronous motor off of the public utility transmission line with a load of about 100 kw., due to the air-compression action in the unaflow cylinder. The unit was run for two hours in this way; the cylinder lubrication being taken care of by the hand pumps.

Incidentally, the condenser was found to leak 5,500 lb. of water an hour from the circulating water into the inside of the steam space. This was later reduced to 350 lb. by repacking the tubes.

The writer would like to learn from any reader if the engine could have been started from a standstill at all without additional switchboard equipment, by the alternator. Also, would a two-phase or single-phase alternator have acted the same?

As I understand it, a direct-current machine would have to have the leads reversed, and in that case the engine would be started with the switch out, gotten up to speed, then the throttle closed and the switch thrown in, whereupon the generator would run as a motor. Otherwise polarity would be reversed.

Hamilton, Ohio. MARSHALL L. BARKER.

How Operating Conditions of Plant Were Improved

A new engineer recently took charge at the industrial plant with which I am connected, and he lost no time in taking steps to improve the conditions of the plant.

Upon looking over the equipment, he discovered among other things that the condensation from a hot-water generator in the basement was discharged through a trap to the sewer, as shown by the dotted lines in Fig. 1, also that the bypass was kept open owing to the trap's being out of order. He immediately took steps to have this condensation returned to the receiver into which the returns from the heating system and process were collected.

This receiver was of the mixed-return type, having a vacuum pump connected at the top to handle the air and a float-controlled duplex pump connected at the bottom to handle the condensation.

The receiver was located ten feet above the hot-water generator, and the problem was how to get sufficient

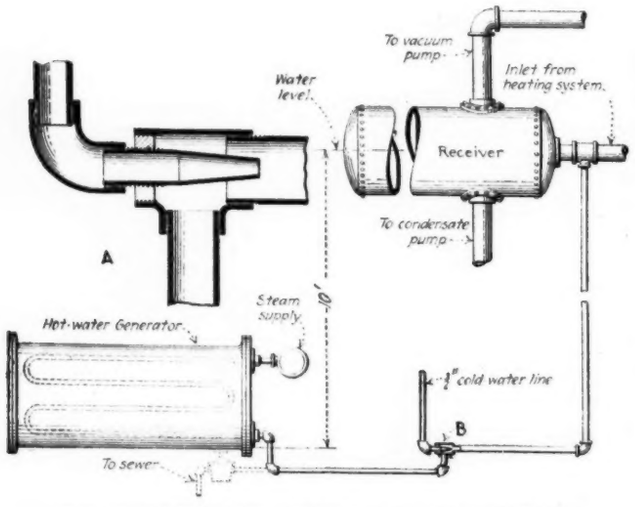


FIG. 1—DETAIL OF NOZZLE AND CONNECTIONS

vacuum to draw this water up the ten feet. At first he tried speeding up the vacuum pump, but, owing to the temperature of the water in the receiver which was about 192 deg. F., sufficient vacuum could not be produced. He then devised the following method of handling the water: A ½-in. pipe nipple was drawn out to form a nozzle, and this was inserted in a 1-in. tee as shown in detail at *A*, Fig. 1. The tee was then placed in the line at *B* and the nozzle connected to the discharge of the pump which supplied the heater with makeup water. As the amount of makeup was about 30 per cent of the total water used, the ½-in. valve on the line to the nozzle was kept wide open most of the time. The suction that was produced by the nozzle was sufficient to keep the generator drained.

After this condensation was returned to the receiver, the amount of makeup water was reduced nearly one-

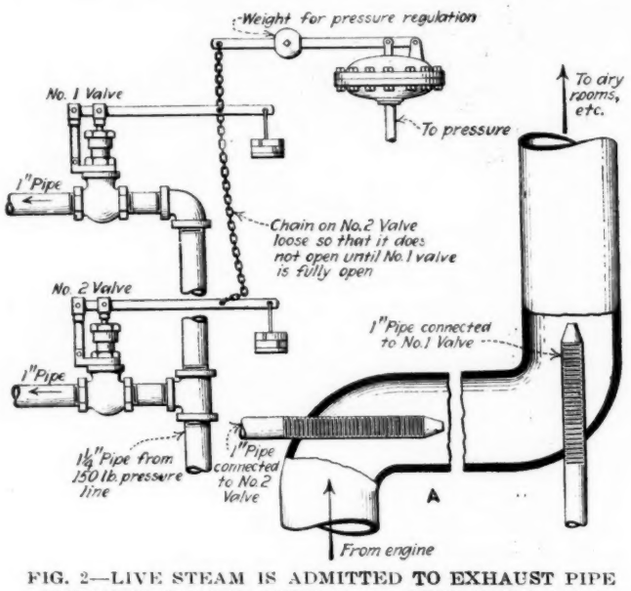

Weight for pressure regulation
No. 1 Valve
To pressure
To dry rooms, etc.
1" Pipe
Chain on No. 2 Valve loose so that it does not open until No. 1 valve is fully open
No. 2 Valve
1" Pipe connected to No. 1 Valve
1" Pipe
1½" Pipe from 150 lb. pressure line
1" Pipe connected to No. 2 Valve
A
From engine

FIG. 2—LIVE STEAM IS ADMITTED TO EXHAUST PIPE THROUGH NOZZLES INSTEAD OF REDUCING VALVE

half and considerable difference was shown in the accumulation of scale in the boilers and in the amount of fuel used. He then turned his attention to the engine that was running rather noisily, which the previous engineer explained was due to its being out of line, and as the load was heavy it lagged considerably at times.

At the first opportunity he examined the cylinder and found that the rings were broken and that the piston had about ⅛-in. clearance. New rings were ordered, and after they were put on, the engine ran much better but the load was still more than it could handle nicely. The engine operated against 5 lb. back pressure, and the exhaust-steam supply to the heating and process was supplemented by live steam through a 3-in. reducing valve that opened intermittently.

The engineer decided to further improve the operating condition of the engine by reducing the back pressure. He accordingly had two nozzles installed in the exhaust pipe, as at *A*, Fig. 2, and taking the diaphragm from the reducing valve, had it connected so that when the pressure rose it would open two 1-in. valves which were connected as shown.

The No. 1 valve was connected with a tight chain so that it would open full before No. 2 would open, thus giving a constant flow. The weights on the valve levers were just sufficient to close the valves. After these nozzles were installed, the pressure on the driers remained at 5 lb. while the pressure at the engine was 1½ lb. when the valves were opened wide and about 3 lb. when they were about one-half open. As the quantity of live steam used was considerable, the valves were open most of the time and the reduction in back pressure, in addition to the new piston rings, made a big improvement in the operation of the engine.

Philadelphia, Pa. R. J. WEST.

Comments from Readers

Motor-Driven Compressor Should "Run Under"

In the Feb. 13 issue P. J. S. asks the question, "Should a horizontal motor-driven ammonia compressor be run under or over?" While I agree substantially with the answer given, the direction of rotation depends to some extent on the method of driving.

If the compressor is direct-connected it can be operated conveniently in either direction. On the other hand, if it is belt-driven it may not be possible to run it under because the tight side of the belt is on top and the slack side has to drag on the floor. This of course depends on the relative location of the motor and compressor, which in many cases is governed by location and space rather than by a preference for running the compressor under.

D. BRIDGES.

Hugo, Okla.

Operation of Separating Calorimeter

In the Feb. 6 issue is a good description of the Carpenter separating calorimeter, in which I am glad to note that attention is called to the fact that there is no appreciable difference between the pressure, and hence, the temperature, in the central chamber and that in the jacket space, and thus there can be no flow of heat through the intervening wall. Consequently, the initial quality of the steam as it enters the inner chamber is maintained, and no correction for heat loss is necessary in using the instrument.

The history of the development of this instrument might be of interest to the readers of *Power*. In the early days of the throttling calorimeter, Professor Carpenter, who was then in charge of the mechanical laboratory at Sibley College, Cornell University, made the throttling calorimeter applicable to the determination of the quality of steam of any moisture content by attaching it to the discharge from a small steam separator, into which the steam sample was led. By doing this, the quality of the steam entering the calorimeter was brought within the range of the instrument, and by measuring the water drawn off from the separator and determining the steam discharged from the calorimeter by condensing it, the quality of the original sample of steam could be determined. He discovered, on trying out this plan, that the velocity of the steam in the small separator was so low that practically all the moisture in the steam was deposited in the separator, so that, after correcting for radiation loss, the quality of the steam indicated by the calorimeter was found to be dry and saturated. The result was that by using an orifice of the size of that used in the throttling calorimeter as the final steam discharge opening for the separator, the separator itself automatically became an excellent calorimeter.

It might also be interesting to describe how the radiation loss from the original type of unjacketed separating calorimeter was determined. The method used was to connect two separating calorimeters of exactly the same dimensions in series, but removing the discharge orifice from the one that first received the steam. The result was that in the first calorimeter was deposited the original moisture in the steam and the moisture due to radiation loss from the calorimeter walls, so that the steam leaving this calorimeter and entering the second one was dry and saturated; therefore, all the water deposited in the second one was due to radiation loss from its walls. As the two calorimeters had equal radiating surfaces and were at the same temperature, the radiation loss from the first was the same as that from the second, so that separating the moisture in the second from that deposited in the first gave the original moisture in the steam.

The instrument shown in the illustration on page 227 of the Feb. 6 issue was the final result of the experiments carried out with the jacket feature added.

New York City. G. B. PRESTON,
Mechanical Engineering Department,
United Y. M. C. A. Schools.

Saving Coal Through the Use of Steam Jets

Referring to the article entitled, "Report 15 Per Cent Coal Saving Through Use of Steam Jets," in the issue of Jan. 16, the amount of saving appears out of proportion with the equipment installed. I recently took CO_2 readings on a hand-fired boiler on which two over-fire steam jets of ½-in. pipe each had been installed, as well as a turbo-blower under the grates, the fuel being a mixture of anthracite and bituminous coal. A summary of the results follows:

Item No.	Conditions	Average CO_2 Per Cent	Approx. Overall Efficiency at 500 Deg. Flue Gas, Per Cent
1	Turbo-blowers operating, steam jets not operating	9	69
2	Turbo blower and steam jets operating	7.2	61
3	Natural draft, steam jets not operating	5.7	58
4	Natural draft, steam jets operating	5.3	55

From this summary it appears that there is an improvement in efficiency of 11 per cent between items 1 and 3, but that the steam jets cause a loss in each case. This amounts to 8 per cent between items 1 and 2, and 3 per cent between items 3 and 4. However, no account has been taken yet of the steam consumption of the jets. This amounts to an additional loss of 1.6 per cent, making the actual loss due to use of the steam jets 9.6 per cent between items 1 and 2, and 4.6 per cent between items 3 and 4.

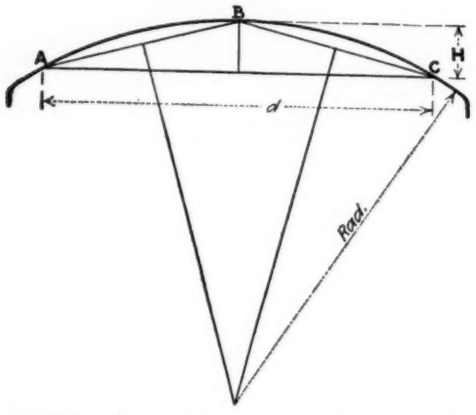
As the installation amounts to undergrate blowers and over-fire jets, the difference between items 2 and 3, as enumerated, would correspond, and in the case under my observation this produced a gain of 3 per cent in coal saving, or, deducting 1.6 per cent for jet steam, a net gain of but 1.4 per cent. The boiler tested was operating approximately at rating.

Philadelphia, Pa. F. V. WETHERILL.

Graphical Solution of Problems

Several articles have appeared recently in *Power* with reference to formulas or their use. It seems to me that not enough stress has been laid on the graphical solutions of the problems involved. The algebraic solution of problems using complicated formulas is good practice for students of mathematics, but for the practical engineer the solving of a problem by means of a straightedge, scale and triangle is easier and quicker and usually gives results sufficiently accurate for practical purposes.

For example, take the problem of finding the radius of a bumped head by the formula $R = \frac{d^2}{8H} + \frac{H}{2}$ given in the Feb. 27 issue. This is not what may be called a complicated formula, but many an engineer



GRAPHICAL METHOD OF FINDING RADIUS OF BUMPED HEAD

would prefer the graphical solution. From actual measurements taken on the head, the three points *A*, *B* and *C* can be located on a sheet of paper, either full size or to any suitable scale. It is then a simple matter to pass a circle through these three points, and thus get the required radius. Take a specific case: Let *H* equal 8 in. and *d* equal 60 in. Using a scale of 3 in. equals 1 foot, or one-fourth size, *H* equals 2 in. and *d* equals 15 in. Passing a circle through the points *A*, *B*, *C*, thus located, the radius measures 15⅛ in., equivalent to the full size radius of 60½ in. This is the same value that is obtained for *R* by solving the formula mathematically.

In this particular case the graphical solution gives an accurate result, and it seldom varies from the mathematical solution more than 2 per cent.

Bridgeport, Conn. D. FLIEGELMAN.

Bending Copper Pipe

I read with interest the article on "Bending Copper Pipe" by Frank Richards in the March 6 issue.

I do not think the fact that the rosin is in compression causes the pipe to burst, because copper, being soft, will yield rather than compress the solid rosin. In my opinion the reason the pipe breaks is because during the bending process the solid rosin naturally breaks through its weakest section and the rest of the rosin then tends to stick to the walls of the copper pipe in the same way that concrete bonds to reinforcement. The stretch in the pipe is therefore localized and restricted to the portion surrounding the crack through the solid rosin. It stretches almost entirely in that local area, the elastic limit is passed and it breaks in that same section, the remainder of the pipe remaining practically undistorted.

It stands to reason that copper pipe plus the solid rosin is stronger than the copper pipe surrounding the broken section.

A good way in which to prevent breakage of this kind is, after melting the rosin and permitting it to cool, to tap the pipe all around from the outside so that the rosin will break up into small pieces. After it is broken or even pulverized, danger of breakage is practically eliminated. F. M. REILLY.

Newark, N. J.

Removing Scale from Pipes with Muriatic Acid

I read with interest the articles in the Feb. 20 and March 20 issues on the use of muriatic acid in removing scale from pipes, water jackets, etc.

It is perfectly true, as stated, that under certain conditions muriatic acid will remove scale, especially when it is of a calcium-carbonate formation, since muriatic acid will combine chemically with this salt with the liberation of gas and the formation of a soluble salt, calcium chloride.

It must be borne in mind, however, that muriatic acid and other acids, which would have a like effect, are extremely powerful corrosive agents so far as iron, steel, brass, etc., are concerned, and even though extreme precautions are taken in employing it for removal of incrustation, the acid will exert its corrosive action on the metal in various places throughout the apparatus or lines to be treated. The acid, therefore, removes not only the incrustation, but also a certain amount of metal, depending on how long the metal is exposed to the action of the acid. The amount of metal removed is not such a serious factor unless the treatment is frequently employed, but it is a well-known fact that the corrosion that is started by acid has the ability to continue even after the original cause has been removed.

In other words, the use of powerful corrosive acids naturally starts up local seats of corrosion, which, while not evident to any appreciable extent at the completion of the acid treatment, are a source of future trouble unless extreme care is taken that every trace of acid be thoroughly removed by use of strong alkalies; even then there exists a possibility of future trouble due to the acid's getting into small cracks and crevices, where it will continue its action.

The use of acid, therefore, for scale removal in expensive engine installations and pipe lines, is in my opinion poor practice. I remember that over twenty years ago certain engineers made a practice of putting hydrochloric, or as commonly termed "muriatic acid," directly into steam boilers for the purpose of clearing out the injector, piping, and the boilers themselves. Needless to state, this resulted disastrously in many instances.

The removal of scale from boilers, pipe lines, engine jackets, condensers, etc., can be accomplished efficiently and safely with certain treatments which have been developed after careful study and research, and therefore it is not necessary to resort to methods that involve the use of reagents having a powerful destructive action on the metal. E. L. GROSS.

Chicago, Ill.

Quick Work in Restoring Service

As much has appeared recently in *Power* on the question or restoring service after an interruption, an account of an accident that occurred recently at our plant and the time taken to restore the service may be of interest.

The night shift came on duty at 11 p.m., and as usual started up a 720-kw. cross-compound engine-driven unit and put it on the load and shut down a 2,000-kw. turbine. The unit had been on the load about forty minutes, when suddenly the engine began to pound, and before it could be shut down a cylinder head was knocked out. As it was impossible to get to the throttle to close it, the engineer and fireman had to shut the stop valve on each boiler.

As soon as the steam stopped blowing through the engine, the wiper closed the throttle, and then the steam was turned back on the header. The turbine-driven unit was started again with as little delay as possible, and the generator switch was closed, so that the frequency and voltage would build up on the system as the unit came to speed. From the time the cylinder head blew out until the service was again normal, was exactly twelve minutes. T. K. MURRELL.

Meridian, Miss.

Waste-Heat Economizer Idea Not a Recent Development

I was interested in the description of the Mitchell Waste-Heat Economizer in the Feb. 20 issue, because I happen to be familiar with a somewhat similar device used about fifty years ago and known as Stead's generator. It consisted principally of pipes placed in the firebox and combustion chamber of horizontal return-tubular boilers, and some were even stuck through the tubes in order to increase the heating surface. The protection of the brickwork was a special point emphasized by the promoters of the generator.

The following results of a boiler test made May 23, 1878, at the Faber pencil works, Greenpoint (Brooklyn, N. Y.), may be of interest. The boiler was fitted with a Stead's circulating generator, adding 99 sq.ft. of heating surface to the 665 sq.ft. of the boiler proper. The grate surface was 18 sq.ft., average steam pressure 44 lb. gage, and the temperature of the feed water 62 deg.

The test lasted 11 hours and the total coal consumed was 2,484 lb.; total combustible, 2,180 lb.; total water evaporated, 21,562 lb. The conclusions drawn by Prof. R. H. Thurston state: (1) The boiler having Stead's circulating generator attached, exhibited an unusually high evaporative power equivalent to 10.26 lb. of water from and at 212 deg. per pound of anthracite coal, or 11.67 lb. of water from and at 212 deg. per pound of combustible, thus utilizing 78 per cent of the heat generated by the combustion of the fuel; (2) the boiler exhibited a steaming capacity equivalent to 3.03 lb. of water from and at 212 deg. per square foot of heating surface per hour, or a total of 2,315 lb. of steam per hour; (3) the steam contained only 0.26 per cent moisture, which is remarkable for a boiler having no superheating surface.

Later on they applied about 100 sq.ft. more heating surface and obtained an evaporation of over 2,600 lb. of steam per hour, and I suppose only lack of room for more pipes stopped the evolution.

Bridgeport, Conn. H. F. HEYRODT.

Leaks in Ammonia Condensers

In *Power* of March 20 I note that O. A. Anderson, in an article entitled "Operating Characteristics of Ammonia Condensers," states that one of the disadvantages of the tubular and the double-pipe condensers is the possibility of ammonia leaks occurring without detection. He adds that ammonia leaking into the water may be carried off and discharged to the sewer or to a cooling tower without notice of the engineer.

I do not think that he intends to convey the idea that an ammonia leak in a double-pipe condenser would act in this manner, for the reason that the double-pipe ammonia condensers on the market at the present time have an open gland between the ammonia packing and the water packing, and an ammonia leak would be more readily discovered than it would with an atmospheric type of condenser. Tubular condensers would, however, have the disadvantage he mentioned.

Chicago, Ill. M. R. CARPENTER.

How Fuel Bill Was Cut in Half

Since much is being said at this time regarding the high cost of coal for fuel an account of the way we cut our fuel costs in half may be of interest.

We are operating a water, light and power plant producing an average of 2,000 kw.-hr. and pumping around a half million gallons of water daily. We formerly used from 9 to 11 tons of coal in 24 hours, costing from $5 to $5.50 a ton. When another advance in price became inevitable, we began planning how we could reduce the coal consumption. There are several small "plants" in the vicinity, making ax handles and other products from virgin hickory, of which there is an abundance through this section of the country and fortunately one was located close to our plant. We installed a 700-ft. chain conveyor to bring the waste over, and made arrangements with the owners to electrify their mill, agreeing to supply the current in exchange for the fuel. We also put two teams to work hauling from the other mills, including a hardwood band mill the refuse from which we bought for a few cents a cord, making the cost delivered average about $1 a cord.

This resulted in a reduction of 50 per cent in our coal bill, and in a short time we will be doing even better, as we plan to use a motor truck of our own which will cut the haulage bill to less than half.

It was necessary to employ two helpers in the boiler room, but with their wages added to the waste-fuel cost, the net saving was $25 per day. The electrifying of the mills, cost of conveyors, etc., ran around $2,600, which we consider well invested.

West Point, Miss. GEORGE L. BROCK.

According to a recently issued booklet on the fatigue of metal, by C. E. Stromeyer, chief engineer, Manchester Steam Users Association, there are several reliable methods of determining the fatigue point under alternating stress. When the fatigue limit is reached, what may be called molecular friction takes place in the metal. This generates heat which can be detected by delicate thermocouples. At the same time the elastic properties of the material undergo a change, which can be determined by suitable instruments. The association has conducted a long series of experiments on the subject of fatigue and has published the results in a special booklet of 46 pages.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Heating Surface of Return-Tubular Boiler

What is the heating surface of a horizontal return-tubular boiler 72 in. in diameter by 18 ft. long, containing seventy 4-in. tubes? F. E. B.

All surface of a boiler in contact with fire or hot gases on one side and water on the other side is called heating surface. In a return-tubular boiler the heating surfaces consist of the under side of the shell, the interior surface of the tubes and part of the heads, the amount of shell and head surfaces depending on the character of the setting.

When considered regardless of the setting it is customary to assume that the heating surface is equal to two thirds of the shell, the external surface of all tubes and two thirds of the net area of both tube sheets after deducting the area taken out by the tube holes.

Taking all dimensions in inches,

	Sq.In.
The heating surface in the shell would be $\frac{2}{3}$ of (72×3.1416) $(18 \times 12) =$	48.858.1
Heating surface of all tubes would be $(4 \times 3.1416)(18 \times 12)70 =$	189,955.9
Gross area of each head $= 72 \times 72 \times 0.7854 =$ 4,071.5 sq.in.	
Area of 70, 4-in. tube holes $= (4 \times 4 \times 0.7854)70 =$ 879.6 sq.in.	
Net area of one head after deducting tube holes, 4,071.5 — 879.6 = 3,191.9 sq.in.	
Heating surface in one head $\frac{2}{3}$ of 3,191.9 = 2,127.9 sq.in. and for two heads = 2 127.9 × 2 = ...	4,255.8
Total	243,069.8 sq.in.

or 243,069.8 ÷ 144 = 1,687.9 sq.ft. of heating surface.

Starting Four-Stage Impulse Turbine

How should a four-stage impulse turbine with a LeBlanc jet condenser be started up after being idle for a week, and what is the general practice in starting turbines? H. E. L.

First turn on steam to seal the turbine, close the vacuum breaker, then start the condenser and, when 27 in. of vacuum is obtained, turn on the water until the proper amount shows in the glass. It is the usual practice to admit enough steam to turn the machine over, then close the throttle, and afterward crack the throttle valve slightly so that the machine will warm up while it is revolving. It was the practice many years ago to warm up Curtis turbines before turning them over, but in recent years the general practice is to turn the machine over quickly with steam and then heat it up while it is revolving slowly. After an interval varying from five minutes to a half-hour, depending on the type of machine and number of stages, the turbine can be speeded up.

In starting turbines in general, however, this procedure is not always advisable, as with some reaction turbines it is preferred to start up non-condensing or at a light vacuum and heat up thoroughly before putting on the operating vacuum.

In small machines of one stage, there is less difficulty in starting, as they are more rigid and less sensitive to vibration than multi-stage machines. Ordinarily, small machines may be heated first and then turned over if desired, but the uniform practice of turning over first and then heating, is equal to or possibly better than the other method.

Heat Content of Gas at Reduced Pressure

If a natural gas has a calorific value of 1,000 B.t.u. per cu.ft. at 4 ounces of pressure, how would the calorific value be affected if the gas is expanded to twice the volume? L. D. M.

Calorific value is based on the heat content per pound weight of the gas. When quoted per cubic foot, the density, or weight of a cubic foot, usually is assumed to be the density which the gas would have at 32 deg. F. and standard atmospheric pressure of 29.92 inches of mercury or 14.7 lb. per sq.in. The "high" calorific value is that which would be obtained by separate perfect combustion of the ingredients The low heat content is the high heat value less the latent heat absorbed by evaporation of compounds like water that may result from the combustion, thereby detracting from calorific value.

If the gas is expanded from a higher to a lower pressure without doing work or sustaining refrigeration from an external source, the temperature would remain constant. If heat is lost in performance of work or from cooling, the temperature would be lowered, but in either case the product of combustion would be the same per pound weight of the gas when considered as the heat developed above the temperature which the gas may have at the inception of combustion.

Natural gas at the pressure of 4 oz., or 0.25 per sq.in. above the pressure of the atmosphere would have an absolute pressure of 14.7 + 0.25 = 14.95 lb. per sq.in. When expanded to twice the volume and same temperature, the absolute pressure would be $\frac{1}{2}$ of 14.95 = 7.475 lb. per sq.in. absolute or 14.7 — 7.475 = 7.225 lb. per sq.in. below the atmosphere. The density or weight per cubic foot and the heat content per cubic foot then would be only one-half as much as at the pressure of 4 oz. above the atmosphere, or 14.95 lb. per sq.in. absolute. Of course if expansion occurs to a pressure below

the pressure of the atmosphere, it becomes impossible to effect discharge of the gas to burn it in the atmosphere.

It is to be noted that the density or weight per cubic foot is inversely as the absolute pressure and not inversely as the pressure above the atmosphere. Thus if the pressure of 4 oz. per sq.in. above the pressure of the atmosphere, or 14.95 lb. per sq.in. absolute, is reduced to 2 oz. above the pressure of the atmosphere, or 14.7 $+ \frac{2}{16} = 14.825$ lb. per sq.in. absolute, and at the same temperature the weight per cubic foot becomes $\frac{14.825}{14.95}$ or 0.99164 as much, or only about $\frac{84}{100}$ of 1 per cent less. Hence if the gas contains 1,000 B.t.u. per cu.ft. at 4 oz. pressure above the atmosphere, there would be 991.16 B.t.u. or only 8.4 B.t.u. less per cu.ft. for the pressure of 2 oz. above the atmosphere.

Generation of Steam in Closed Tank Filled with Water

Can steam be generated in a closed tank totally filled with water? M. L. O.

If an ordinary steel tank is filled with water at room temperature and then (after closing all outside connections) is heated, no steam will form, but the tank will ultimately burst from the expansion of the liquid. There are, however, several unusual conditions where steam might be formed. One case would be that of a tank made of an elastic material like thin rubber, in which the water could expand to a volume corresponding to the increased temperature, and the vessel could expand to accommodate the volume of steam generated. Again if water at very high temperature (600 or 700 deg. F.) and a pressure above the steam-table pressure corresponding to the temperature were pumped into a rigid steel tank and all valves closed, the water would shrink greatly on cooling, leaving a space that would become filled with steam.

As still another example, imagine a tank filled with water just below the critical point (about 706 deg. F.). Then a very slight increase in temperature would turn the whole mass into steam of only slightly greater volume than the water. By delicate adjustment this slight expansion might take place without bursting a steel tank.

Stress on Screw End of Through Stay

Through stays of boilers are secured to the heads by means of inside and outside nuts. If the outer nuts are first screwed up, producing a tension of 6,000 lb. in the body of the stay and the inner nuts are then tightened to produce a tension of 12,500 lb. between the inner and outer nuts and each stay supports 100 sq.in., what will be the tension between the nuts when the boiler is placed under a pressure of 100 lb. per sq.in.? T. E. P.

This problem cannot be solved without knowing the resistance which the heads offer to various amounts of deflection from tension of the stay and also the dimensions of the stay and compressibility of the head material.

When the outside nut *A*, Fig. 1, is first screwed up to produce a tension of 6,000 lb., with the inner nut *B* clear as shown, the screw-threaded portion between the nuts is subjected to the tension of 6,000 lb. like the body of the stay.

When the inner nut is then screwed up against the boiler head as in Fig. 2 to produce a tension between the inner and outer nuts of 12,500 lb., the threaded portion *C* between the nuts becomes further elongated and the amount of this elongation is transferred to the body of the stay and portions like *D* between the body and inside nuts.

This elongation permits the heads to spring outward, resulting in less than 6,000 lb. tension in the body of the stay, the amount depending on the resistance to buckling when the tension on the stay is equal to the buckling resistance of the heads. With no movement of the heads the stress of 6,000 lb. on the body of the stay would be reduced by only the amount that would be required to elongate the body of the stay by the length which the section *C*, Fig. 1, was stretched from increasing the load on *C* from 6,000 lb. to 12,500 lb., and the net amount would depend on the relation of the length

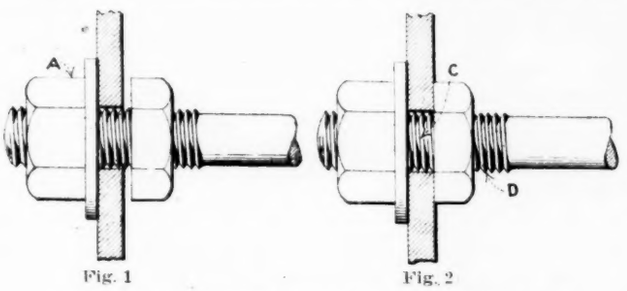


Fig. 1 Fig. 2

BEFORE AND AFTER SETTING UP CHECK NUTS OF THROUGH STAY

of *C* to the whole length of the stay between inside check nuts or other fastenings. With through stays of ordinary length and no movement of the heads the reduction would be only about $\frac{1}{100}$ of the initial load, or in the present case the load would become about 5,985 lb., making the load on *C* due to setting up the inside nut equal to 12,500 — 5,985 = 6,515 lb.; then if the body of the stay supports 100 sq.in. pressure or 10,000 lb. instead of 6,000 lb., the total stress on the section *C* still would be 12,500 lb.

Also if the load on the stay that is balanced by resistance of the head after taking up the inside nut is less than the tension on the body of the stay would be without deflection, then the total stress on *C* would be the same and would become more only if the load on the stay became more.

Keying up Rod With Strap, Gib and Key

In keying up an engine connecting rod fitted with straps, gibs and keys, what should be the position of the crank, and how should the keying be adjusted? C. T.

Place the crank at about 90 deg. with the line of the stroke, or, more particularly, in that position where the greatest diameter of crankpin is in line with the rod. Drive the key up to a firm bearing with a soft hammer, then make a scratch mark on one side of the large end of the key at the face of the strap and back out the key a little, but no more than necessary to make the pin run cool in the brasses. The scratch mark will serve as a guide for indicating the amount of variation made in the adjustment of the key.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering

The Meaning of Exponents

SUCH expressions as the following occur frequently in engineering formulas: 7.2^2, 6^3, $16^{\frac{1}{2}}$, $a^{\frac{3}{4}}$, $9.6^{1.2}$ and $12^{-0.6}$. In each case the expression means that the number or letter written on the line is to be raised to the power indicated by the "exponent" written in small figures at the right and above the line. The first two expressions given will be recognized at once as the square and cube respectively. That is, 7.2^2 means that 7.2 is to be raised to the second power, or taken as a factor 2 times, as follows: $7.2 \times 7.2 = 51.84$. In the same way $6^3 = 6 \times 6 \times 6 = 216$. Similarly 6^5 means that 6 is to be raised to the fifth power, or taken as a factor five times as follows: $6 \times 6 \times 6 \times 6 \times 6 = 7{,}776$. In each of these cases the exponent was a whole number and not preceded by a minus sign. In all such cases the exponent shows how many times the number is to be taken as a factor.

The cases where the exponent is a fraction or negative (has a minus sign before it) require further explanation. Let us first consider fractional exponents, taking as an example the expression $9^{\frac{1}{2}}$. To say that 9 is here to be taken as a factor one-half times would not mean anything, so a new point of view is necessary. Without going into the reason why, it may be simply stated that $9^{\frac{1}{2}}$ means the same thing as $\sqrt{9}$. Likewise $8^{\frac{1}{3}} = \sqrt[3]{8}$, and any other fractional exponent whose numerator is 1 means that the root indicated by the denominator is to be taken.

Now suppose we have the expression $9^{\frac{3}{2}}$. This means that we are to cube the number and take the square root. The order makes no difference. If we cube the number first, we have: $9^3 = 729$; $\sqrt{729} = 27$. Taking the square root first and then cubing, gives the same answer as follows: $\sqrt{9} = 3$; $3^3 = 27$.

The fractional exponent may happen to be a decimal as in $16^{0.75}$. Since 0.75 is the same thing as $\frac{3}{4}$, we may write this $16^{\frac{3}{4}}$, which is solved as follows: $\sqrt[4]{16} = 2$; $2^3 = 8$. Again, take $4^{2.5}$. This becomes $4^{\frac{5}{2}}$ and is easily solved as follows: $\sqrt{4} = 2$; $2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$.

These examples were easily handled because the decimal exponent reduced to a simple fraction in which the denominator stood for a root that could easily be extracted. Suppose the expression were $11.2^{1.34}$, as might occur in figuring the expansion of gas in an internal-combustion engine. While the decimal 1.34 can be written $\frac{134}{100}$ or $\frac{67}{50}$, it would evidently be an all-night task to take either the hundredth or fiftieth root of a number by the try-and-fit process explained for square root and cube root in the March 6 issue. The only practical way to handle such exponents is to use logarithms or else a slide rule or a special diagram based on logarithms. These methods, which are easy and rapid when clearly understood, will be explained in subsequent lessons. For the present we will stick to simple fractions which, while illustrating the principles of exponents, can easily be handled by methods already explained.

What is the meaning of a negative exponent as found in the expression $9^{-\frac{1}{2}}$? This is the same thing as $\frac{1}{9^{\frac{1}{2}}} = \frac{1}{\sqrt{9}} = \frac{1}{3}$. Similarly $8^{-\frac{2}{3}} = \frac{1}{8^{\frac{2}{3}}} = \frac{1}{4} = 0.25$. In other words, any number with a negative (minus) exponent is equal to the reciprocal of that number with the minus sign removed.

It frequently happens that a number raised to a certain power is multiplied or divided by the same number raised to another power. Where the powers are whole numbers and have no minus signs, it is easy to see what happens. If, for example, 3^2 is to be multiplied by 3^5, it is evident that the answer must be the product of 3 written seven times since 3^2 is 3×3, and 3^5 is $3 \times 3 \times 3 \times 3 \times 3$. In other words $3^2 \times 3^5 = 3^7$, the original exponents being added to get the final exponent.

In division the exponents are subtracted, so $3^7 - 3^5 = 3^2$. This can be proved by writing out the operation as the product of seven threes divided by the product of five threes. Five pairs of threes will cancel out, leaving 3×3 or 3^2. Although the proof is not so simple, these same rules for multiplying and dividing apply to fractional and negative exponents. For example $4^{\frac{1}{2}} \times 4^{\frac{3}{2}} = 4^1 = 4^2 = 16$, and $9^{0.5} \div 9^{0.0} = 9^{-0.5} = \frac{1}{9^{0.5}} = \frac{1}{\sqrt{9}} = \frac{1}{3}$.

Sometimes it is desired to get the power of a power, or the power of a root which is really the same thing. For example, we might want to write the cube of the square root of 4 as 4 raised to some power. This can be done as follows: $(\sqrt{4})^3 = (4^{\frac{1}{2}})^3 = 4^{\frac{3}{2}}$. In such a case the exponents are multiplied to get the final exponent.

As an example bringing in a number of the principles already given, consider the following:

$$\frac{2^{\frac{1}{2}} \times 2^{-2.5}}{(2 \times 2^{\frac{1}{2}})^2}$$

This is easily simplified if the work is carried out in short steps. The first step is to simplify the numerator. Since the two quantities are multiplied the exponents must be added. The algebraic sum of $\frac{1}{2}$ and -2.5 is -2, so the numerator becomes 2^{-2} or $\frac{1}{2^2}$. In the same way the denominator reduces first to $(2^{\frac{3}{2}})^2$ and then to 2^3, so the fraction becomes $\frac{1}{2^2} \div 2^3 = \frac{1}{4} \div 8 = \frac{1}{32}$.

Rotary Air Compressors at Increased Speed and Capacity

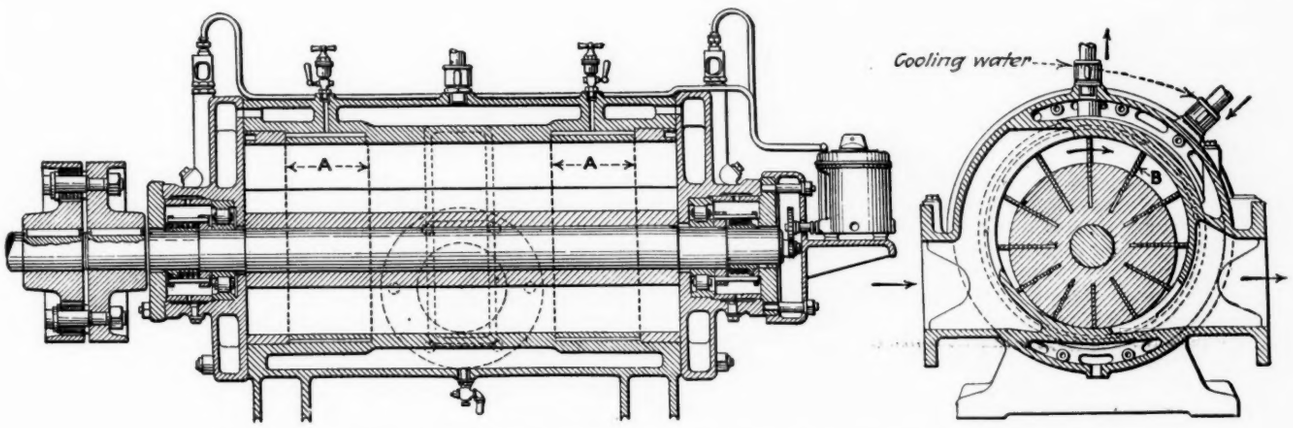
The rotary air compressor, which has been developed for smaller capacities and higher pressures than turbo-blowers, is now being produced at four to six times the original speed in Switzerland, as a result of recent improvements described in a recent issue of *Engineering* (London). While it is possible that a similar principle may have been applied in other countries, this idea will undoubtedly appear as a novelty to most readers.

Ordinary construction involves a rotating element, eccentrically located in a cylinder as at *B* in the illustration. Radial blades carried by the rotor are free to move toward or away from the cylinder, so as to follow the internal contour as they revolve. Air is admitted at the maximum volume of each cell formed between blades and is discharged at minimum volume, 180 deg. from admission. Pressure is therefore practically independent of speed, unlike the turbo blower or centrifugal fan.

The improvement introduced in such machines manufactured by the Swiss Locomotive and Machine Works, of Winterthur, Switzerland, consists in preventing the vane tips from contacting with the cylinder, by placing a freely rotating sleeve between. This sleeve rotates in the cylinder, as indicated at *A*, showing provision for sleeve and cylinder lubrication. The vanes are therefore guided in their radial movement by this ring, which rotates at the same speed, reducing friction of the blade tips with the cylinder; instead of friction being caused by the full centrifugal force of each blade, the acting pressure is the difference of centrifugal force of opposed blades, which is maximum at the admission position, owing to the difference in their effective radii.

Less strain is carried by each blade, owing to the decrease of tip friction. The sleeves are made as thin as possible with clearance to the cylinder depending on elastic deformation and heat conditions. The problem is to reduce friction as well as produce an approximately airtight joint between neighboring cells. Holes are bored radially through the floating rings, to maintain equal pressure inside and outside. Auxiliary axial vanes, placed in grooves in the sleeves, act as packing seals against leakage in the clearance to the cylinder.

Power for driving is greatly reduced. Commercial compressors are limited ordinarily to 60 lb. per stage on account of heat liberated. By compounding and cooling, however, this pressure may be greatly exceeded, two-stage machines having been built to deliver 230 lb. per sq.in. For the same number of revolutions per minute, floating rings make possible an increase in diameter of 50 per cent and a consequent increase of 125 per cent above the original capacity. In a given machine these rings make a 50 per cent increase of speed possible without excessive wear. Compressors of this type have been run as high as 3,000 r.p.m., giving practically no pulsation in discharge pressure.



SWISS AIR COMPRESSOR WITH REDUCED FRICTION AND INCREASED CAPACITY

Improved Method of Firing Abates Smoke and Saves Fuel

Tests conducted by the mechanical engineering division of the Bureau of Mines at one of the government power plants which serves a department building in Washington have established that improved methods of firing not only abate smoke from the use of bituminous coal, but create a saving in fuel consumption while at the same time making no more work for the firemen than old methods.

The tests were conducted in connection with changes by which the furnaces were modified at a cost of $1,000 and resulting, in combination with improved firing, in a saving of $12,500 annually in the coal bill. The changes consisted of raising the bridge wall slightly and putting an arch over it to increase the combustion space and give time for the gases to mix and swirl instead of going straight to an outlet. Firemen were instructed to fire at more frequent intervals and to control by the dampers instead of the ashpit doors. The result was that this plant which heretofore had used anthracite because it was unable to keep within the smoke regulations when using bituminous, easily keeps within the regulations and effects a saving in fuel.

In order to determine the effect upon personnel, tests were made of firing before the change in the furnaces with both anthracite and bituminous coal, under the old methods, and with bituminous coal by the improved method of firing after the change was made. Improved firing is to put in fuel at more frequent intervals, in smaller quantities, firing one half of the grate at a time, thus getting the benefit of the coked fire on the other half; and to rake down the fire instead of using bars through them. Barring, it was found, creates smoke, while raking does not. The new method of loading the fires half at a time insures more complete and even combustion.

The new method of firing requires about the same actual work as did firing with bituminous coal under the old method. Firing with anthracite under the old method required more time because the higher ash content made more frequent cleaning necessary and the lower heat content increased the amount of firing necessary to produce 1,000 lb. of steam.

The time spent on the boiler per 1,000 lb. of steam, including firing, cleaning and other work, under the old method, using anthracite, was found to have been 2.38 to 2.94 min.; the time under the old method, using bituminous, was 1.88 to 2.08 min., and the time under the improved method, using bituminous, was 1.87 to 1.97 minutes.

While the time for firing bituminous under the old and new methods is practically the same, installation of the new method requires supervision until the firemen become accustomed to firing in smaller amounts regularly and to keeping the fires in good condition at all times. This supervision is the price of more complete combustion without objectionable smoke, and its compensation, according to the tests, is a

saving of $0.0685, or 16 per cent, in the cost of fuel per 1,000 lb. of steam.

Under the modified operating conditions at this plant, with bituminous coal, there was an increase in efficiency with a decrease in rating. From each 176 heat units with anthracite, under the old conditions, 100 heat units were absorbed by the boiler; from each 176 heat units with bituminous, under the old conditions, 104 heat units were absorbed by the boiler; and from each 176 heat units with bituminous, under modification of the plant and improved firing methods, 123 heat units were absorbed by the boiler in generating steam.

Boston Engineers Discuss Sources of Power

At an affiliation meeting of the Boston engineering societies on March 28, the subject of fuel and power was discussed from the viewpoints of coal, oil and water power.

The subject of coal was dealt with in a paper by George B. Harrington, president of Wilmington & Franklin Co., of Chicago. Mr. Harrington reviewed the production and utilization of coal as set forth by the United States Geological Survey and then passed to the recent troubles in coal supply. While conceding that the coal industry is badly organized and functions uneconomically, he stressed the labor conditions as largely responsible for the situation and expressed the opinion that things would straighten out normally if the industry could be assured of no more strikes.

Voicing the opinion of the operators, Mr. Harrington said that they were not so opposed to the principle of unionism as they were to a monopoly of labor as represented by one large union practically under the dictation of one man. As a result the seven thousand individual mine operators of the Midwest fields, prevented by legal restrictions from combining, were at a decided disadvantage when it came to conferences.

The speaker predicted marked progress in the development and application of mechanical loaders in the near future. These make for a big saving in labor.

Factors Governing Fuel Oil Production

George S. Davison, president of the Gulf Refining Co., Pittsburgh, briefly traced the history of petroleum from its discovery in this country in 1859 to the present, with no less than twenty states actively producing it. The increase in production during the last 42 years has been as follows: 1880, 26,286,000 bbl.; 1900, 63,620,000 bbl.; 1920, 442,929,000 bbl.; 1922, 551,197,000 bbl.

Last year the United States produced 64.7 per cent of the world's supply and Mexico 21.8 per cent. The gross consumption in this country, including imports, was over 650 million barrels. The speaker dealt with the factors going to make up the cost of producing petroleum products, touching upon land speculation in the oil fields as a large factor, the cost of storage, pipe-line investment, pumping and refining, and in addition the risk involved, for there is much drilling that does not result in flowing wells and the flows of many wells are of short duration due to the seams being tapped in adjacent holdings. Moreover, the pipe-line companies will take the oil no faster than is dictated by the demand, and there is now some oil in Oklahoma that has been stored in tanks for the last 15 years, during which time investment charges on tanks and taxes have been going on and the oil has been losing by evaporation much of its gasoline content.

The price of fuel oil, Mr. Davison said, is largely governed by the price of competitive coal and the price of the other petroleum products, such as gasoline, kerosene, lubrication oil, etc., will be such as to allow the fuel oil to compete with coal and at the same time cover the crude oil cost and insure a profit on it. The average price received for crude, figured on the price of its components, is about $3.75 per barrel.

During the last year the gasoline demand increased 25 per cent, and although the cracking processes are getting more and more gasoline out of the crude, as long as the gasoline demand keeps up there should be a plentiful supply of fuel oil.

There are two grades of Mexican crude, the light of around 22 deg. Baumé with a 10 to 12 per cent gasoline content, and the heavy having a gravity of around 12 deg. Eighty million barrels of the light oil was brought into the United States last year, a large portion reaching New England. The heavy oil, on account of its almost negligible gasoline content, is burned direct without refining. The heavy-oil production is keeping up, but the light Mexican oil fields are nearing exhaustion.

Water Power from an Economic Viewpoint

"The cost of producing water power today bears about the same relation to cost with coal as it did ten years ago, owing to increased labor and material prices," said C. W. Kellogg, of Stone & Webster, whose paper treated largely of the economic aspects of water-power development. But while the average increase in hydro efficiency had been about 10 per cent, the corresponding increase in efficiency through production from steam had been close to 90 per cent. Therefore a water-power development to compete with steam must cost about 35 per cent less per unit initial cost, allowing for price advances during recent years.

Mr. Kellogg traced the influence of electrical development upon the utilization of water power and gave some interesting figures on estimated transmission costs, showing the influence of load factor. He claimed that while it would be possible to transmit 250,000 kw. 300 miles at 220,000 volts for 2¼ mills, if the load were dropped to 50,000 kw. the cost would run up to 7¼ mills.

Another factor in financing water powers, as distinguished from steam plants, is that the major portion of the development usually has to be made and financed at the start, whereas steam plants built upon the unit plan can be extended as the load demand increases. Furthermore, steam plants can be constructed in much shorter time and the money is not tied up so long without earning a return. This is one of the reasons that a higher rate of return is usually demanded in financing hydro developments.

Although warning against the popular conception of cheap water power, Mr. Kellogg let it be understood that he considered a well thought out and carefully designed water-power development, operating under proper load conditions, as one of the safest kinds of investment.

Welding Cast Iron

The following comments on the welding of cast iron are based on an article in the March issue of the *General Electric Review*.

The term "cast iron" is applied to metal of widely varying composition and characteristics. Cast iron usually contains from 3 to 4 per cent of carbon, but this may be in either the combined or free (graphitic) form, and it may hold widely varying amounts of such other elements as silicon, manganese, sulphur and phosphorus. Not only the presence of these elements, but also the rate of cooling of the castings, profoundly affect the physical characteristics and "weldability" of the metal.

In making a weld in commercial cast iron, the surfaces which are to be joined must again be melted. When these surfaces, which consist of iron containing carbon in both the free and the combined states, are melted, several things happen. First, all the carbon goes into solution in the molten metal. Second, some of the carbon, silicon and manganese is burned out by the heat, while the sulphur and phosphorus are practically unaffected. The tendency, therefore, is to produce a cast iron in the weld that will be white when cold owing to its low content of silicon and carbon. Third, the surface of the molten metal oxidizes, making a slag, which partly prevents further oxidation.

As soon as the welding heat is removed, the melted iron hardens very quickly, giving up its heat to the neighboring cold metal and to the air. The sudden cooling produces a chilled hard white metal in the weld, the hardness being due to the fact that much of the carbon remains in solution if the cooling is sudden. Of course, if the casting has been preheated before welding, the cooling of the added metal will not be so sudden and a softer machineable weld may be secured.

News in the Field of Power

Hydro-Electic Power Bill Introduced

New York Legislature May Amend the State Boards and Commission Law To Create Commissioner of Hydro-Electric Power

UNDER the bill as introduced a most elaborate machinery by and under which the commissioner and bureau established by the act, may, when the funds are available, construct hydro-electric plants on the Niagara and St. Lawrence Rivers on state owned and undeveloped water powers. Transmission lines may also be constructed, if necessary, but to make certain that the electricity will not be allowed to run to waste, all present transmission lines are declared to be common carriers and must transmit the current generated, to the limit of their capacity, no matter what else they are doing, at the commands of the state commissioner of hydro-electric power, who is the state engineer and surveyor, at the price for such transmission which the public-service commission is empowered to fix.

Synopsis as follows:

The bill amends the state boards and commission law by inserting in it a new Article VII entitled "Commissioner of Hydro-electric Power." It provides that the state engineer and surveyor shall be such commissioner and creates a new bureau in his office.

General Powers of the Commission

The Commissioner of Hydro-electric Power shall act as an agency of the State of New York in acquiring, taking over, possessing, controlling and utilizing the waters of Niagara and St. Lawrence Rivers adaptable for power purposes; in developing water power and in generating and developing electrical current, power and energy; in transmitting such current over transmission lines to be constructed, owned and controlled by the state, or otherwise; and in selling such current, power or energy to municipal and other corporations, public or private, and individuals.

He may appropriate, take possession of, use, improve and control any of the lands of the state suitable and essential. He may divert and take from the Niagara River and the St. Lawrence River, or either, such water as he may deem necessary for the purpose of generating and developing hydro-electric power and energy, and may apply, in behalf of the State of New York to the Congress of the United States, or federal authority or to any international body having power, by consent of Congress, to entertain applications for or to grant rights and privileges in behalf of a foreign government or in behalf of both the United States and such a government, for the acquisition by the state of any right or privilege, in relation to the quantity of water to be taken by the state from either or both of such rivers, the duration and diversion by the state, the construction and maintenance of dams, canals, works and structures and otherwise; but this provision shall not be construed as recognizing in the federal government any jurisdiction over the waters of such rivers for power purposes.

He may also construct upon lands acquired by him or upon state lands, or in, upon or over the waters of such rivers, and maintain and operate such buildings, structures, works, plants and power stations, and furnish and equip, maintain and operate, such fixtures, machinery, appliances and apparatus essential or appropriate for the generation, development, conservation or utilization of water power and electrical current; and also may build, construct and erect any and all transmission lines and distributing systems essential or appropriate for the conservation, utilization, transmission, transforming and distributing of electrical current, to the extent that transmission lines and distributing systems then existing and owned by individuals or corporations are inadequate, insufficient or unavailable for the efficient transmission of such electrical energy to the various municipalities or other purchasers or lessees; and also may purchase such quantities or amounts of auxiliary electrical current as necessary to render efficient the service of a power plant.

He may transmit, transform, distribute such electrical power on, over, through, along, under or across any lands or premises, streets, avenues, alleys, highways, canals, rivers, watercourses, bridges, viaducts, railways and public places to any municipality or to any inhabitant of the state when practicable and the requirements of such inhabitant cannot be met adequately by the municipality wherein he resides.

He may contract for the sale or lease and may sell or lease electrical current produced by the state to municipal or other corporations or to individuals, giving preference to municipalities, and may fix just and equitable rates at which he will sell or lease such electrical energy and may change and readjust the same.

Owner or Operator of Transmission Line To Be Common Carrier

Any person or corporation who or which owns or operates a transmission line for the transmission or distribution of electrical current for light, heat or power purposes shall be, for all purposes a common carrier, and shall be deemed to be included within the meaning of the term "common carrier" as used in the public-service commissions law, and subject to all the provisions of the public service commission law. Price to be fixed and determined by the public-service commission.

The commissioner may describe and designate as electrical zones any territory within which he shall deem the power and energy generated at any particular place may be appropriated and economically used and which boundaries may be changed, enlarged or lessened in extent.

Municipalities given power generally to engage in the business of distributing and selling electricity to its inhabitants; price of electricity sold by municipalities must not exceed maximum fixed by commissioner.

Powers of Public Service Commission Limited

The public-service commission shall not have the power to fix, modify or regulate rates made by the state or by a municipal or other corporation or person, for electrical power supplied by the state.

The Commissioner of Hydro-Electric Power may make rules and regulations, which shall have the force and effect of law, governing the procedure for complaints, hearings and determinations respecting rates. The powers confided by this article to such commissioner shall be exercised by him independently of any other commission, board, officer, or department.

If this bill is passed as now written, after the electricity gets to the municipality, the municipality may then compel any existing power corporation to transmit it as a common carrier within its boundaries or may construct its own transmission lines.

The present water-power commission is continued. To private interests it may lease the 59,000 undeveloped horsepower of the barge-canal surplus waters and the approximately 750,000 hp. of the Hudson River watershed under the terms and condition of the Robinson law.

What the measure omitted to do is to provide that before a municipality may engage in the business of selling

electricity, it must procure a certificate of convenience and necessity from the public-service commission so to do and such a requirement is now in the public-service commission law.

The provisions of the Robinson law as to the issuance of permits for the St. Lawrence and Niagara Rivers development are revoked. An appropriation of $1,000,000 is made immediately available and the commission will probably, if the measure becomes a law, ask the legislature of next year for $40,000,000 more or less to carry out its immediate program, but this year nothing is to be told the people about the enormous cost of the enterprise their public servants have undertaken for them.

Mechanical Engineers Needed in Coal Mines

Evidence of insufficient resort to engineering advice impressed John Hays Hammond on his recent visit to the Alabama coal field. He is of the belief that the situation in Alabama is fairly typical of the entire coal industry. Certain companies, he says, make full use of the best available engineering talent, which, he observes, is one of the reasons for the needlessly wide spread between costs of production at different properties. Not only is the advice of coal-mining engineers needed, but there is large opportunity in many coal mines, Mr. Hammond declares, for the profitable employment of mechanical engineers. Many of the problems under ground are mechanical he pointed out.

In some of the Alabama mines, Mr. Hammond says, serious consideration should be given the relative economies which could be introduced by the improvement of underground haulage; by the sinking of more shafts and by the employment of more cutting machines. These improvements, he admits, involve large initial expense, but he believes they should be considered on the basis of ultimate economy. To save long hauls in metal mines, extra shafts frequently are sunk to great depth. While he realizes that a different problem is involved in coal mines, where the volume of the tonnage is so much greater, he points out that there is a corresponding advantage in that the depth of shafts is usually not great.

Commissioner Smith also is impressed with the need for better engineering in many coal properties. In an address he delivered last year, he discussed some engineering phases of the industry. "What engineering can do for the industry is already known," he said at that time, "for we have today large coal mines well laid out and equipped with modern machinery, which show in actual practice how we can better the business of mining coal. Our chief need in this business, as in some others, is merely to raise the average up to the best. Mines planned by engineers and managed by engineers, with the aid of the coal-consuming public, can come much nearer to giving the mine worker an actual opportunity to work eight hours a day and six days a week. Cheaper coal and larger earnings are two ideals which can be attained by engineering after bargaining has failed utterly. The reform of the coal business must be worked out mostly underground."

Hoover Recommends Slowing Down in Public Construction

Upon a request from the Administration, the Department of Commerce has recently made a survey of the situation in the construction trades. It finds that the year 1922 was a year of very large employment and activity and that stocks of materials were much reduced and much advanced in cost, and that since the beginning of the present year there has been even more activity with advance orders for material upon a very large scale. Labor is at full employment with an actual shortage in many directions. Transportation facilities are fully loaded and there is a constant car shortage.

For the government to enter into competition at the present moment would give no additional employment to labor and no additional production in materials and would displace much private construction. The governments, both national and local are in a better position to hold construction work in abeyance than are private concerns and are also able to speed up in times of less demand.

Mr. Hoover recommends that the government initiate no new work not eminently necessary and that there be a slowing down in work in progress, where possible, until after there is a relaxation in private demands.

Would Use New York City Water Supply for Power

Senator James J. Walker, majority leader in the upper house of the New York State Legislature, has introduced a bill (Senate Print No. 1602) amending chapter 734 Laws of 1905, by authorizing New York City to construct, own, maintain and operate power houses, transmission lines and other equipment necessary to generate and convey electric current to New York City for municipal purposes or to sell it to its inhabitants or to any corporation authorized to distribute electricity or to any city, town or village, the current therefor to be generated at city owned reservoirs in the Croton and Catskill watersheds.

Pit River To Have a New Power House

Construction of Pit No. 3, the second of a chain of power houses which will ultimately develop over 600,000 hp. from the waters of the Pit River in northern California, will start within the month, according to an announcement made by John A. Britton, vice-president and general manager of the Pacific Gas & Electric Co. The plant, which will have a capacity of three 27,000-kva. units and involve the expenditure of approximately $17,000,000, will be completed by 1925. It will be located about twelve miles below Pit No. 1 power house.

Installation will involve the construction of a diversion dam 125 ft. high at a point 2½ miles below Pecks Bridge on the highway between Burney and Bartle. From this point a tunnel approximately 22,000 ft. in length, having a capacity of 3,000 cu.ft. per sec., will carry the water to a point above the site of the power house. The initial step will be the construction of the Pit River Railroad. The installation will also require the construction of eight miles or more of double-circuit 220-kv. transmission line from power house No. 3 to the main transmission system.

In connection with the announcement relative to this latest step in hydro-electric development Vice-President Britton stated: "The company in its electric-service side is growing at a rate of twenty to twenty-five thousand kilowatts a year of peak load. Our engineers calculate that the demands for electric energy increase at the rate of 7½ per cent per annum or an increase of 120,000,000 kw.-hr. a year now."

Engineers Have Developed the World but Have Shirked Duties

At the annual banquet of the Connecticut Section of the A.S.M.E., John Lyle Harrington, president of the American Society of Mechanical Engineers, in speaking of the "Function of an Engineer," gave the engineers some pretty straight talk about their duty to the state and the nation. Jack Armour, of *Power*, entertained the company with a speech full of humor.

"Engineers have been unwilling to assume their share of the duties of government in city, state and nation," said Mr. Harrington, "and this is the reason that they have not as a class received the recognition to which the work that they have done in the world entitles them. The engineer is practically no further along in the estimate of the public than he was a century ago, and this is because he works alone and in private. But we know that we must educate our members to take part in the life of the nation if they are to take the place they should in the world."

The Department of Commerce, Scientific Papers of the Bureau of Standards. No. 455—Tables for the calculation of the Induction of Circular Coils of Rectangular Cross Section. Price 10 cents, Government Printing Office, Washington, D. C.

The Department of Commerce, Technologic Papers of the Bureau of Standards. No. 216—Properties of Electrical Insulating Materials of the Laminated Phenolmethylene Type. Price 30 cents. Government Printing Office, Washington, D. C.

New Publications

The Swedish Year-Book, 1922. Issued by the Royal Foreign Office, and published by Almquist & Wickalls Boktryckeri-A-B, Stockholm, Sweden. Cloth; 253 pages.

Printed in English and filled with the latest available information on political, social and industrial conditions in Sweden, as well as statistical and historical matter, it should prove to be of distinct value to readers of *Power* who are interested in Sweden.

The Petroleum Register, for January, 1923, published by the *Oil Trade Journal,* Inc., 350 Madison Ave., New York City. Cloth; 12x9 in.; 431 pages, including advertisements. Price, $10.

A comprehensive directory and statistical record of the petroleum industry; it includes a buyer's guide, index of companies and individuals, lists of refiners, compounders, grease manufacturers, marketers and jobbers, producers of crude petroleum, pipe lines, natural gasoline manufacturers, foreign companies, manufacturers of and dealers in equipment, drilling contractors, traffic guide to petroleum refineries in the United States, trade name used by principal marketing companies, oil associations, books on oil and gas, statistical section and oil maps.

Steam Power. Second Edition. By. Hirschfeld and Ulbricht. Published by John Wiley & Sons, New York. Cloth; 5x7½ in.; 453 pages; 251 illustrations. Price, $3.25.

This is the second edition of a popular text book on steam-power machinery. By reason of the simplicity of treatment it has been quite widely used in elementary engineering classes. The only adverse criticism that can well be offered is that many of the illustrations are of equipment of somewhat antique age. Students as well as practicing engineers should be familiar with modern trends in power-plant design; the ball-and-lever safety valves and boilers with domes have little place in a present-day engineering book. On the whole the authors have produced a work of merit.

Asiatic Markets for Industrial Machinery. By Walter H. Rastall, Trade Commissioner. Published by the Department of Commerce, Special Agent Series, No. 215; 332 pages. Price, 60 cents. Obtainable from the Superintendent of Documents, Washington, D. C.

Asia is rapidly developing in importance as a market for American machinery, having absorbed nearly $242,000,000 worth of such equipment in the last four years. These figures exclude agricultural implements, adding machines, lawn mowers, etc., and include only industrial, such as factory, mining, railway and construction equipment. This report should be of immense value to manufacturers who export, as careful analysis is made of conditions in each of these Asiatic countries, with regard to the various kinds of machinery in demand, the sources from which it has been supplied and the ways in which American manufacturers can secure a better participation.

Machinery Foundations and Erection. By Terrell Croft. Published by McGraw-Hill Book Co., Inc., New York City. Cloth; 5¼x8 in.; 668 pages; 772 illustration. Price, $5.

This volume is one of a series which the author has prepared upon steam power-plant practice. Nothing new is presented beyond the development of formulas for the calculation of foundation bearing surface and volume. Unfortunately, the data given as to safe bearing pressures are so much beyond those encountered in machinery-foundation building that the formulas are of doubtful practical value. The pressure values given evidently are those where some settlement of the masonry is permissible. Needless to say this is quite undesirable in engine foundations. As the author points out, the framing of most machines is such that the area within the foundation bolts exceeds the required area as derived from the formula. Most of the pages are devoted to methods of constructing foundations, aligning and erecting machinery and other data of considerable value to the engineers. While the volume is in many respects a compilation of material that has appeared in various technical publications, this matter is so logical in arrangement and so complete in treatment that a considerable popularity is to be expected for the work. It would seem that it should be of particular benefit to machine designers and erectors, consulting engineers and architects.

Obituary

Seabury S. Gould died Sunday morning, March 25, 1923, at Seneca Falls, N. Y. He was born in the same town Dec. 10, 1848. His early education was obtained from the public schools of Seneca Falls, and Dwight's High School, Clinton, N. Y. Later he attended Hamilton College, from which he graduated in 1868. Upon graduation he immediately became overseer of a blast furnace belonging to his father at Williamsport, Pa. In 1872 he returned to Seneca Falls to become secretary of the Gould's Manufacturing Co. Upon the death of his father, Seabury S. Gould, after whom he was named, he became vice-president and later, upon the death of his brother, president of the company.

The Gould's Manufacturing Co. was established in 1848, but did not bear its present name until 1864, when Seabury S. Gould, Sr., had it changed. The company is known nationally and internationally as the manufacturer of Triplex power pumps and its extensive plant is at Seneca Falls.

Personal Mention

H. R. Wetherell of Peoria, Ill., has been appointed technical secretary of the National District Heating Association.

Dr. Cary T. Hutchinson is now associated with Sanderson & Porter, engineers, 52 William St., New York City, as director of their railroad electrification department.

A. H. Nickerson, who since 1904 has been with the American Agricultural Chemical Co., has resigned in order to accept a position with Stone & Webster, Inc., in their mechanical division.

John M. Nicholson formerly with the Westinghouse Co. in its Boston office has recently accepted the position of manager of the New York District of the Bernitz Furnace Appliance Co., 350 Madison Ave., New York City.

Clifford F. Messinger for the last three years general sales manager of the Chain Belt Co., Milwaukee, Wis., has been elected second vice-president of the company. He entered its employ upon graduation from the Sheffield Scientific School, Yale University, in 1911.

R. J. S. Pigott, who has just completed two years' reorganization work with the Crosby Steam Gage & Valve Co., with which he is still retained in a consulting capacity, has associated himself with Stevens & Wood, Inc., of 120 Broadway, New York City, as mechanical engineer, and will be in charge of the power and industrial work of that company.

C. O. Myers has been reappointed Chief of the Division of Boiler Inspection and Examiner of Engineers for the Industrial Commission of Ohio. The Board of Boiler Rules has been reorganized by the appointment of L. C. Connolly of Cleveland representing the boiler manufacturers, J. H. Vance of of Akron representing the users, L. E. Gregg of Cleveland representing the insurance companies, and Barrett A. Burns of Cincinnati representing the stationary engineers.

Mr. W. Nelson Smith, M.E., consulting electrical engineer of the Winnipeg Electric Railway Co., and **Dr. John W. Shipley,** assistant professor of chemistry of the University of Manitoba, have recently been awarded the Plummer Medal for 1921-22 by the Engineering Institute of Canada for their two research papers entitled, "The Self Corrosion of Cast Iron and Other Metals in Alkaline Soils," and "The Self Corrosion of Buried Lead Pipes." These papers were published in the journal of the Engineering Institute of Canada in October, 1921, and June and July, 1922; and were also reproduced in full in the *Sibley Journal of Engineering,* published at Cornell University, in March and November, 1922.

Society Affairs

The Birmingham, Alabama, Section of the A. I. & S. E. E. will hear G. H. Finks, of the Alabama Power Co., speak on "Inter-Connection Industrial Power Plants with a Central System" on April 21, 1923.

The National Exhibitors' Association, connected with the N. A. S. E. convention which will this year be held at the Auditorium in Buffalo, is busy arranging for its annual exhibit. Applications for space are coming in fast and most of the good locations have been taken, although there are a few choice booths left. F. N. Chapman, 5909 Kennerly Ave., St. Louis, Mo., is the secretary of the Exhibitors' Association.

The American Chemical Society, New Haven, Conn., will hold a symposium on motor fuels on Friday, April 6, at 9:30 a.m. S. W. Sparrow will speak on "Fuel Requirements of Internal-Combustion Engines;" F. W. Lane and A. V. Bower on "Economic Aspects of Motor Fuel Supply from Petroleum;" Frank A. Howard and N. E. Loomis on "Refinery Problems Affecting Motor Fuel Supply;" H. A. Gardner on "Suggestions on Absolute Alcohol as a Possible Constituent of Motor Fuels;" W. F. Huff on "Coal-Tar as a Source of Fuel for Internal-Combustion Engines."

The A. S. M. E. has the following papers on the program for its Los Angeles meeting, April 16-18, 1923: "Hydro-Electric Development of Southern California Edison Co.," by H. Barre; "The Flow of Crowds," by C. H. Benjamin; "Oil Venturi Meter," by Ed. F. Smith, Jr.; "The Cross-Flow Impulse Turbine," by Forrest Nagler; "The Diesel Engine," by H. W. Crozier. The program also includes a trip to Pasadena to visit the California Institute of Technology for the inspection of the physics laboratory and to hear a paper by Prof. Royal W. Sorenson on "Problems Involved in Designing Extremely High-Voltage Transformers," an inspection of the laboratory and shops of Mt. Wilson Observatory and a trip to the oil fields of Santa Fe Springs and Signal Hill.

Business Notes

The Standard Turbine Corp. announces the following appointments of sale representatives: Fred H. Dorner, 548 Milwaukee St., Milwaukee; Craun-Liebling Co., 30 Euclid Ave., Cleveland; I.. S. Vallely and Co., Whitney-Central Bldg., New Orleans; Leonard G. Paine, 806 Otis Bldg., Philadelphia; Castle & Wilson, 1601 Arrott Bldg., Pittsburgh.

The Girtanner Engineering Corp., formerly of 1400 Broadway, New York City, has been made subsidiary of the American Brake Shoe and Foundry Co., with offices at 30 Church St., New York City., and will now enlarge its activities of manufacturing and installing steam ash and soot removal systems and other boiler-house equipment.

Reading Iron Co., Reading, Pa., has secured the services of Lawrence F. Whitney for its New England sales organization. The district office will be at 161 Devonshire St., Boston, Mass.

Coming Meetings

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, April 16-18; Spring meeting at Montreal, Canada, May 28-31.

American Chemical Society, Gas and Fuel Section; R. S. McBride, Colorado Bldg., Washington, D. C. Motor fuel symposium at New Haven, Conn., April 6.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, April 18-20.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Spring meeting at Pittsburgh, Pa., April 24-26.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Association of Engineers; C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

National Association of Manufacturers; George S. Boudinot, 50 Church St., New York City. Annual conference, New York City, May 14-16.

American Water Works Association, 163 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

American Boiler Manufacturers Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

American Order of Steam Engineers; W. J. Brice, 1428 Callowhill St., Philadelphia, Pa. Annual convention at Philadelphia, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

Canadian Association of Stationary Engineers; Gorgon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th annual convention at Toronto, Canada, June 25-28.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Kansas,** at Fort Scott, April 4-6; C. H. Taylor, 517½ W. 6th St., Topeka. **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ohio, June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., July 12-14; James F. Morgan, 53 Devonshire St., Boston, Mass.

Cement Gun Co., Inc., announces the resignation of W. J. Roberts as president of the company and the election of B. C. Collier to fill the vacancy. Mr. Collier has for several years occupied the position of vice-president and general manager of the company.

Trade Catalogs

Timing Device, Portable, General Electric Co., Schenectady, N. Y. Bulletin No. 46653, describing a device that consists of an encased clock to be used with a standardized clock as a means of secondary timing, to supplant the stop-watch.

Flow Meters—Republic Flow Meters Co., Chicago, Ill., Bulletin OC-15 describes the operation and construction, reading instruments and methods of wiring the Republic flow meters. Diagrams and charts are given for measuring the flow of fluids by electricity.

Spray Nozzles and Adjustable Spray Heads—Yarnall-Waring Co., Philadelphia, Pa. Bulletin N-610, describing the use of the Yarway involute spray nozzles and Yarway adjustable spray heads in the cooling of water for various purposes, especially in condensing systems.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Mar. 19, 1923	Mar. 26, 1923
Pool 1,	New York	$4.00–4.75	$4.00–4.50
Smokeless,	Columbus	4.25–4.75	4.25–4.75
Clearfield,	Boston	2.65–3.50	2.25–3.00
Somerset,	Boston	3.00–3.75	2.75–3.50
Kanawha,	Columbus	2.50–2.75	2.50–3.00
Hocking,	Columbus	2.25–2.50	2.35–2.60
Pittsburgh No. 8	Cleveland	2.65–2.75	2.25–2.50
Franklin, Ill.,	Chicago	3.25–3.50	3.00–3.25
Central, Ill.,	Chicago	2.50–2.75	2.50–2.75
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	1.75–2.00	1.85–2.25
S. E. Ky,	Louisville	2.50–3.00	2.50–3.25
Big Seam,	Birmingham	.....	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—March 29, Port Arthur light oil, 22@25 deg. Baumé, 5¼c. per gal.; 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago—March 24, 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $2.39 per bbl. in tank cars.

Philadelphia—March 26, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklohoma (group 3), 3¼@3¾c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

St. Louis—March 26, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95@$2 per bbl.; 26@28 deg., $2.05@$2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 32@36 deg., gas oil, 5¼@5½c. per gal.; 36@40 deg., distillate, 5¾c. per gal.

Pittsburgh—March 12, f.o.b. local refinery, 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.; 34 deg., neutral, 10c. per gal.

Dallas—March 23, f.o.b. local refinery, 26@30 deg., $1.60 per bbl.

Cincinnati — Feb. 27, 26@28 deg. Baumé, 5¾c. per gal.; 28@30 deg., 5¾c. per gal.; 38@40 deg., distillate, 7c. per gal.

Cleveland — Feb. 27, 26@28 deg., Baumé, 6¾c. per gal.

New Plant Construction

PROPOSED WORK

Ariz., Tucson—The Bd. Educ., c/o Lyman & Place, Archts., 79 North Stone Ave., will received bids until April 10 on revised plans for the construction of a 2 story high school. Estimated cost $750,000. Separate bids will be asked for forced draft heating system, furnace heat, refrigeration machine and various motors. Former bids rejected.

Ark., Fayetteville — The city, Water Works Dept. will soon be in the market for large oil pump engines for pumping water.

Calif., Long Beach—E. M. John, et al., 1020 East 2nd St., are having plans prepared for the construction of a 12 story newspaper plant and office building on Bway. Cost will exceed $750,000. W. H. Austin, 1st Natl. Bank Bldg., Long Beach, Archt. Equipment detail not reported.

Calif., Los Angeles—The Los Angeles Cotton Mills Co., E. M. Fowler, Pres., Metropolitan Bldg., is having plans prepared for the construction of the first unit of cotton factory, consisting of 40 x 40 ft. boiler house, 80 x 80 ft. bleaching building, 40 x 80 ft. cloth building, 45 x 55 ft. storage building, 30 x 45 ft. platform, 125 x 175 ft. weaving shed, and 75 x 125 ft. yarn mill. Three other units will be built later. Total estimated cost $4,000,000. M. H. Merrill & Co., 50 State St. Boston, Mass., engr.

Calif., San Francisco—The Medico-Dental Bldg. Corp., c/o G. W. Kelham, Archt., Sharon Bldg., is having plans prepared for the construction of a 12 or 15 story physicians' office building on Mason and Post Sts. Estimated cost $1,250,000. Equipment detail not reported. Noted Dec. 26.

Calif., San Francisco—The Purch. Dept. of the Pacific Gas & Electric Co., 445 Sutter St., received bids for steel for the construction of a 17 story office building at Market and Beale Sts., approximately 2,800 ton. Estimated cost $1,150,000. C. H. Snyder, 251 Kearny St., San Francisco, Engr. Bakewell & Brown, 251 Kearny St., San Francisco, Archts. Noted May 26.

Calif., San Francisco—J. C. Shipp, Pres. Sierra Securities, Inc., et al., 486 California St., is having plans prepared for the construction of a 12 story apartment building to contain 132 apartments, with 3 story garage, etc., on California and Mason Sts. Estimated cost $2,000,000. B. G. McDougall, 381 Bush St., San Francisco, Archt. Equipment detail not reported.

Calif., Venice — The Imperial Ice Co. is in the market for machinery and equipment to increase capacity of ice plant from 50 to 102 tons per day.

Calif., Willits — The Central Mendocino County Power Co., E. Morris, Ch. Engr., will receive bids until about Apr. 10 for materials to be used in connection with concrete dam, estimated cost $25,000; 3,000 ft. of 12 in. wood stave or iron pipe and 17,000 ft. of 12 in. concrete pipe line, estimated cost $20,000. The construction of power plant and transmission line will be undertaken at a later date.

D. C., Washington—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., will receive bids until Apr. 16 for an ice making and refrigerating plant at the U. S. Veterans' Hospital, Chelsea, N. Y.

Fla., Key West—The Monroe County Com. will receive bids until Apr. 5 for 30 hp. boiler, delivery to be made at Miami.

Ga., Canton—The Coggins Marble Co. is in the market for two 125 hp. boilers or one 250 hp. boiler.

Ill., Chicago — The Chicago Auditorium Assn., c/o R. F. Clinch, 209 South La Salle St., plans to build a 25 story hotel, theatre and office building on Michigan Ave. and Congress St. Estimated cost $15,000,000. Engineer or architect not selected.

Ill., Chicago—Silverman & Goldberg, c/o Loewenberg & Loewenberg, Archts., 111 West Monroe St., are having plans prepared for the construction of an apartment building on Hyde Park and Dorchester St. Estimated cost $1,000,000. Equipment detail not reported.

Ia., Des Moines—W. Lister, 507 Youngerman Block, is in the market for a 65 hp. horizontal tubular boiler, 100 lb. pressure.

Ia., Dubuque — The city voted $325,000 bonds for the construction of improvements to waterworks system, including new pumping station, pump equipment, etc. O. E. Carr, City Mgr., is in the market for two air compressors, coal bunkers, stokers and ash handling equipment for the pumping station. Mead & Seaston, State Journal Bldg., Madison, Wis., Engrs.

Ia., Mason City—E. O. Broaten, Archt., 604 M. M. A. Bldg., will receive bids until May 1 for the construction of a 3 story hospital, consisting of a 40 x 206 ft. main building and a 40 x 120 ft. wing for the St. Luke Lutheran Hospital. Estimated cost $250,000. Equipment detail not reported.

Ia., Muscatine—The Bd. of Electric Light Trustees will receive bids until Apr. 18 for the construction of a municipal electric light plant and system, consisting of (1) complete steam power plant, building, equipment and waterworks pumping equipment; (2) complete electric distribution system, street lighting system and substation building and equipment; (3) complete ornamental street lighting system in business district, including regulators and switchboards in substation. A. L. Mullergren, 555 Gates Bldg., Kansas City, Mo., Engr.

Ia., Oskaloosa—The city voted $370,000 bonds for the construction of a municipal light and power plant, including dam on Des Moines River to furnish 4,000 hp. and a 2 story power house, etc.

Kan., Wichita—P. Benson, 402 Orpheum Bldg., contractor, is in the market for a 25 hp. firebox boiler.

Ky., Bardstown—W. O. Stiles, representing syndicate, has purchased site and plans to build a 6 or 7 story hotel. Estimated cost $300,000. Engineer or architect not selected.

Ky., Louisville—The Citizens Hotel Co. has had plans prepared for the construction of an 18 story hotel to contain 19,000 sq.ft. of floor space, on 5th and Walnut Sts. Estimated cost $3,000,000. B. B. Davis, Norton Bldg., Louisville, Archt. Equipment detail not reported.

Ky., Louisville—The Masonic Widows & Orphans Home, 2nd St. between B and C Sts., J. Garnett, Starks Bldg., Chn. Bldg. Com., has purchased a 124 acre site and plans to build a group of buildings on Shelbyville Rd. Estimated cost $1,200,000.

Ky., Walton—J. L. Reeves is in the market for ice manufacturing machinery and equipment.

Md., Baltimore—S. T. Williams, Engr., 223 North Calvert St., is in the market for a 40 to 50 kw. motor generator set, motor a.c. 220 volt, 3 phase, 60 cycle, generator 220 volt, d.c.; or motor and generator as above at different speeds with belt or silent chain drive.

Mass., Boston—The Boston Lodge of Elks, c/o M. F. Culliney, 10 Somerset St., has purchased site and plans to build an 11 story, 100 x 150 ft. building to contain stores, gymnasium, dining rooms, ballroom, lodge rooms and dormitories, on Tremont and Warrenton Sts. Estimated cost $2,000,000. Engineer or architect not selected.

Mass., Fall River—The Fall River Electric Light Co., 185 North Main St., The Edison Illumination Co., 62 Main St., Brockton, and the Blackstone Valley Gas & Electric Light Co., 231 Main St., Pawtucket, R. I., are having preliminary plans prepared for the construction of a power house, 30,000 kw. capacity, on Mount Hope Bay; high tension steel tower lines between Fall River and Pawtucket, and Fall River and Brockton. Stone & Webster, Inc., Milk St., Boston, Engrs.

Mass., Springfield — The city plans to build dikes, pumping stations and new sewer lines to remedy flood conditions which occur annually in the Lowell St. district. Metcalf & Eddy, 14 Beach St., Boston, Consult. Engrs.

Mass., Springfield—The Com. on City Property will receive bids until Apr. 10 for the construction of a 2 story, 90 x 100 ft. addition to high school on Elliot St. Estimated cost $750,000. E. C. and G. C. Gardner, 33 Lyman St., Springfield, Archts. Equipment detail not reported.

Mass., Worcester—The Worcester Hannemann Hospital, 261 Lincoln St., is having plans prepared for the construction of a 3 story addition, including power plant. Estimated cost $300,000. Fuller & Delano, 44 Front St., Archts. Kandall, Taylor & Co., 93 Federal St., Boston, Assoc. Archts.

Mich., Detroit—The B. F. Keith Theatre Co., 720 Euclid Ave., Cleveland, plans to build a 3 story vaudeville theatre, including central steam heating system, here. Estimated cost $3,000,000. Engineer or architect not selected.

Mich., Detroit—The Pere Marquette Ry. Co., Fort St. Union Depot, is having plans prepared for the construction of a 1 story engine terminal and roundhouse, including steam heating plant, water supply equipment, turn table, coach yard and track connections, on 21st St. Estimated cost $1,200,000. H. A. Cassil, Ch. Engr.

Mich., Jackson—The city is having preliminary plans prepared for the construction of additions to city water system, including 3,000,000 gal. storage reservoir; high pressure pumping station with boilers and equipment; high pressure mains; six drilled wells approximately 350 ft. deep; low pressure equipment, consisting of 15 in. motor driven centrifugal pump; water main extensions. Estimated cost $400,000. Hoad, Decker, Shoecraft & Drury, Ann Arbor, Engrs. Noted Jan. 2.

Minn., Duluth—The City, F. S. Snively, Mayor, will receive bids until about April 30, for the construction of a 4 story, 126 x 200 ft. city hall building, including steam heating system on First St. and 4th Ave. Estimated cost $800,000. German & Jenssen, 411 Exchange Bldg., Archts. and Engrs.

Minn., Jackson—The city plans the construction of municipal heating plant and mains. Estimated cost $79,000.

Minn., Virginia—The city plans to enlarge central heating station and extend heating mains. Estimated cost $150,000.

Miss., Cruger—The town, W. J. Smith, Mayor, E. G. Hogan, Clk., will receive bids until Apr. 10 for the construction of a municipal electric lighting plant. Kramer Eng. Co., Magnolia, Engrs.

Mo., Kansas City — The city retained Fuller & Maitland, Engrs., 600 Warren St., to prepare plans for a new water plant. Estimated cost $11,000,000.

Mo., Kansas City—The New Process Co., 836 Lee Bldg., (oil filtering), is in the market for stills, boilers, condenser, box, pipe, oil pump, also oil filtering and reclaiming equipment.

Mo., St. Louis—J. Feldman, 116 North 8th St., has purchased site and plans to build a 16 story, 60 x 130 ft. hotel on Fine St. Estimated cost $1,000,000. Engineer or architect not selected.

Mo., St. Louis—Mauren, Russell & Crowell, Archts., Chemical Bldg., will receive bids until Apr. 10, for the construction of a 5 story, 160 x 269 ft. reserve bank building on Broadway for the Federal Reserve Bank of St. Louis, Bway. and Pine St. Estimated cost $2,500,000 to $3,000,000. Equipment detail not reported. H. H. Morrison, Fullerton Bldg., Engr.

Mo., Seligman—The Silver Lake Mining Co., T. R. Gilliam, Purch. Agt., is in the market for a 100 hp. boiler, steam engine, crushers, belting, hangers and pulleys.

Neb., Omaha—C. and R. C. Cook, c/o George & Co., City Natl. Bank Bldg., will soon award the contract for the construction of a 4 story, 135 x 260 ft. store and office building, including heating plant, on 16th and Howard Sts. Estimated cost $1,000,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Archts. Noted Feb. 20.

N. J., Newark—Leiman Bros., 175 Christie St., are in the market for a fuel oil engine, 50 to 75 hp. capacity.

N. Y., Buffalo—The city is having preliminary plans prepared for the construction of a 3 story, 220 x 260 ft. natural science building on Humbolt Parkway. Estimated cost $1,000,000. Esenwein & Johnson, Ellicott Sq., Buffalo, Archts.

N. Y., Geneva—The Geneva Ice Cream Co. is in the market for complete machinery and equipment for 30 ton daily production ice plant. G. A. Wegner, 12 Amherst St., Rochester, Consult. Engr.

N. Y., New York—St. Marks Hospital, c/o Hunt & Hunt, Engrs. and Archts., 28 East 21st St., is having plans prepared for the construction of a hospital building at 233 East 11th St. Estimated cost $500,000. Equipment detail not reported.

N. Y., Poughkeepsie—The Bd. of Public Wks., Eastman Park Mansion, will receive bids until Apr. 12 for the reconstruction of the pumping station. Hazen & Whipple, 30 East 42nd St., New York, Consult. Engrs.

N. Y., South Edwards—The Power Corp. of New York plans the development of a hydro-electric station, 10,000 hp., on the Oswegatchie River. Cost will exceed $500,000. W. P. Creager, Northern New York Trust Co. Bldg., Watertown, Ch. Engr.

N. Y., Watertown — J. W. Ackerman, City Mgr., and P. B. Sutton, City Engr., will receive bids for three 2,250 kw. generators, (to be connected vertically to turbines), switchboard and transformer equipment for new power plant at Delano Island. Estimated cost $75,000 to $100,000.

N. C., Chapel Hill—The State is having plans prepared for the construction and equipment of various college buildings and dormitories. Estimated cost $1,650,000. H. W. Chase, Chapel Hill, Pres. T. C. Atwood, Chapel Hill, Archt.

N. C., Charlotte—The city and Mecklenburg County are authorized by act of legislature to build a 12 story office building including city, county, court house and jail. Estimated cost $1,000,000. M. E. Boyer, Trust Bldg., Archt.

N. C., Charlotte—The Textile Office Bldg., c/o W. L. Stoddart, Engr. and Archt., 9 East 40th St., is having plans prepared for the construction of a 15 story office building. Equipment detail not reported.

N. C., Fayetteville — The Public Wks. Comn., H. J. McBuie, Secy., will receive bids until Apr. 5 for improvements to the city water works and sewerage system, including miscellaneous improvements to pumping and filter plants such as equipment of present filters with new manifold and strainer systems, rate controllers, loss of head and rate of flow gauges and the furnishing and installation of one chlorinator, one motor driven centrifugal pump, one Venturi meter, etc.; construction of various buildings. W. C. Olsen, Kinston, Engr. Noted Sept. 12.

N. C., Greenville — H. A. Underwood, Engr., Commercial Bank Bldg., Raleigh, will receive bids until Apr. 4, for the remodeling and construction of building for the East Carolina Teachers College, here, a state institution. Estimated cost $950,000. Equipment detail not reported.

N. C., Saluda—The City is having plans prepared for a new water supply system, consisting of approximately one mile of pipe, 200,000 gal. cap. reservoir and pump-

Ohio, Cleveland—The City received bids for the construction of a 180 x 193 ft. pumping station for Fairmount Pumping Station from Shirmer O'Hara Co., 2031 Euclid Ave., $519,918; Camp Constr. Co., Newman Stern Bldg., $559,000; P. Kirschner Co., 1104 Prospect Ave., $567,000. Noted Mar. 6.

Ohio, Cleveland—The Ohio Bell Telephone Co., 4300 Euclid Ave., C. P. Cooper, Genl. Mgr., has purchased site and plans to build an 8 story, 74 x 198 ft. telephone exchange building on Huron Rd. and East 8th St. Estimated cost $1,000,000. A. N. Symes, 4300 Euclid Ave., Engr. Architect not selected.

Ohio, Dayton—The Miami Valley Hospital, Apple St., plans to build a 3 or 4 story addition to its hospital. Estimated cost $500,000. Engineer or architect not selected.

Okla., Nowata—The city is having preliminary plans prepared for waterworks improvements, consisting of the rebuilding of the pumping station, modern rapid sand mechanical filtration plant, water main extensions and storage reservoir. The Benham Eng. Co., 512 Gumble Bldg., Kansas City, Mo., and Oklahoma City, Okla., Engrs. Noted Jan. 2.

Okla., Ponca City—The city plans election Apr. 3 to vote on $80,000 bond issue for the construction of an addition to power and light plant, including two 750 kw. oil engine units, to increase capacity. A. M. Stalnaker, City Engr.

Okla., Tulsa—The Hotel Tulsa, 3rd and Cincinnati Sts., is having plans prepared for the construction of a 10 story addition to its hotel building, including the installation of a high pressure boiler plant, also refrigerating and ice plant. B. Meyer, Box 477, Tulsa, Engr.

Pa., Bethlehem—The Chapman Slate Co. plans complete electrification of its plant and is in the market for motors, controllers and other electrical equipment.

Pa., Erie—The Erie Lighting Co., F. B. Hofft, Vice Pres., plans to build an addition to station on Front St. and to install additional generating equipment. Cost will exceed $25,000.

S. C., Charleston—The E. P. Burton Lumber Co., Cosgrove Ave., plans to rebuild its lumber mill and power house, which was destroyed by fire. Estimated cost $400,000. Engineer or architect not announced. The owner is in the market for machinery and equipment.

S. C., Chester—The Bd. of Trustees, M. E. Brockman, Supt., will receive bids until Apr. 11 for the construction of a high school building, including heating system. Edwards & Sayward, 609 Chamber of Commerce Bldg., Atlanta, Ga., Archts.

S. D., Rapid City—The State School of Mines, T. W. Dwight, Pres., will receive bids until April 10, for the construction of a boiler house and coal bunker, one chimney, induced draft fan, breeching, feed pumps, steam piping, etc., for heating plant. Estimated cost $40,000. Black Hills Eng. Co., Engrs. Noted Oct. 17, 1922.

Tenn., Chattanooga — The Tennessee Power Co., Hamilton Natl. Bank Bldg., plans to build a 30,000 hp. steam plant adjoining the hydro-electric station at Hale's Bar, including installation of 2 boilers for generating steam for the turbine unit. The electric generating unit will consist of turbine and generator to develop 30,000 hp., total capacity 90,000 hp. for plant. Estimated cost $1,500,000.

Tenn., Fayetteville—J. L. Dorsey is in the market for a 12 to 20 ton ice plant, including boiler large enough to furnish additional power for other machinery.

Tenn., McKenzie—The City Council plans to build a municipal ice plant. Cost between $40,000 and $50,000. Engineer or architect not announced. The owner is in the market for ice manufacturing machinery and equipment.

Tex., Fort Worth—J. H. Johnson and associates, 1215 Penn Ave., plan to build a 10 story, 100 x 264 ft. family hotel building. Estimated cost $700,000. Engineer or architect not announced.

Tex., Rockwall—The E. R. Canady Drug Co. is in the market for a 60 cycle, 110 volt motor.

Va., Stuart—W. H. Clark is in the market for one electric generator set, 80 kw.

Wash., Aberdeen — The Grays Harbor Veneer Co., A. A. Bator, Purch. Agt., is in the market for a 60 hp. boiler, 40 hp. engine and machinery for complete veneer plant at Hoquiam.

Wis., La Crosse—The Weisse Mfg. Co., Caledonia and Gillette Sts., will soon award the contract for the construction of 1 story factory buildings, including a 72 x 200 ft. main building, 28 x 40 ft. boiler house, 60 x 64 ft. shed, 26 x 60 ft. glazing building and 34 x 36 x 52 ft. shaving bin. Estimated cost $60,000. O. J. and R. E. Sorenson, 216 Main St., La Crosse, Archts.

Wis., Marshfield—The City Water Comn., A. L. Brownell, Supt., is having plans prepared for an electrical generating unit for municipal light plant. Private plans.

Wis., Milwaukee—The Central Produce Co., c/o J. A. Padway, 603 Caswell Block, is in the market for refrigeration machinery, several ton capacity.

Wis., Milwaukee — A. L. Richards, 90 Mason St., plans to build a 2 and 11 story, 100 x 100 ft. L-shaped hotel on 2nd St. Estimated cost $400,000. Engineer or architect not selected.

Wis., Milwaukee — W. Schroeder, 86 Michigan St., is in the market for an ice machine, capacity 5 to 10 ton.

Wis., Wauwatosa—The Bd. of Public Wks. received bids for furnishing deep well turbine or centrifugal pump, Aurora Pump & Mfg. Co., Aurora, Ill., $5,967 and $6,681; Layne & Bowler Co., Chelsea Ave., Memphis, Tenn. $7,522. Noted Mar. 13.

Wis., Wauwatosa — P. Kuehlhorn, Burleigh Rd., R. F. D. (meat products), is in the market for medium size refrigeration machinery.

Ont., Cobalt—The town, A. W. Harrington, Clk., plans to install an auxiliary pumping plant, including gasoline engine and centrifugal pump, in connection with waterworks system. Estimated cost $20,000.

Ont., Fonthill—The town is having plans prepared for the installation of a waterworks system, including 6 in. mains, hydrants, valves, centrifugal electric pumps and pumphouse. Cost between $40,000 and $50,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs.

Ont., Ottawa—The Ottawa Hydro-Electric Com., 109 Bank St., J. E. Brown, Genl. Mgr., will receive bids until Apr. 5 for a nine panel, 12,000 volt switchboard.

Ont., Peterboro—The ratepayers passed a bylaw for the construction of an electric light and power distribution substation with transformers, switches, lightning arresters, etc. Estimated cost $75,000.

Ont., Toronto—The Hydro Electric Comn., 190 University Ave., will install additional transformer capacity in their sub-stations at New Hamberg, Norwick, Aylmer and Embro this year. Estimated cost $25,000. F. A. Gaby, 190 University Ave., Ch. Engr.

Que., Buckingham—The town, T. Toupin, c/o Roy & Toupin, Engrs., 502 St. Catherine St., Montreal, Que., Purch. Agt., will receive bids until Apr. 5 for complete equipment for a water power plant.

CONTRACTS AWARDED

Ala., Florence — The U. S. Engineer's Office, War Dept., awarded the contract for one electric generator to the Westinghouse Electric & Mfg. Co., Union Bldg., Pittsburgh, Pa. Estimated cost $6,490. Noted Jan. 30.

Calif., Los Angeles — The Los Angeles Chamber of Commerce, Chamber of Commerce Bldg., awarded the contract for the construction of an 8 story office building on 12th St. to the C. J. Kuback Co., 701 Merch. Natl. Bank Bldg. Approximate cost $2,200,000. Noted Feb. 20.

Ill., Chicago—W. W. Ahlschlager, Archt., 65 East Huron St., awarded the contract for the construction of an 8 story, 200 x 216 ft. hotel on Washington Blvd. and Homan Ave. to Shank & Co., 30 North La Salle St. Estimated cost $2,000,000. Steam heating system will be installed. Owner's name withheld. Noted Nov. 7.

Ill., Plainfield (Joliet P. O.)—The Public Service Co. of Northern Illinois, 72 West Adams St., Chicago, awarded the contract for the construction of an addition to its power plant, here, to Bowie, Lydon & Co., Inc., 340 West Harrison St., Chicago. Estimated cost $200,000.

Mich., Detroit—The Children's Hospital, Farnsworth Ave., awarded the contract for the construction of a 5 story, 150 x 225 ft. nurses' home to H. G. Christman & Co., 315 Stevens Bldg. The contractor will purchase a 2-pipe vacuum steam heating system with equipment. Noted Mar. 27.

Mont., Butte—The Montana Power Co., 40 East Broadway, awarded the contract for the construction of a hydro-electric plant and excavating for pipe line, involving 2,500 ft. of 4 in. steel pipe and 9,000 ft. of 56 in. wood pipe, to the Winston Bros. Co., Columbus. Estimated cost $1,250,000.

N. C., Roxboro—The city awarded the contract for laying 20,000 ft. of 12 in. water pipe; construction of filter plant, pumping station and reservoir; furnishing and erecting equipment, consisting of one 500 g.p.m. centrifugal pump, electric motor and one 500 g.p.m. centrifugal pump with gas engine drive, to Boyd, Higgins & Goforth, Inc., Realty Bldg., Charlotte. Estimated cost $92,571.83. Noted Mar. 6.

Ohio, Columbus—The Bd. Purchase, W. H. Duffy, Pres., City Hall, awarded the contract for the installation of two 200 hp. boilers at the Girls Industrial Home near Delaware, to the Heine Safety Boiler Co., 143 Union Trust Bldg., Cincinnati, $14,230; filtered motor pump to The Factory Engineers & Sales Co., Commerce Bldg., Columbus, $2,119. Noted Mar. 6.

Ohio, Rocky River—The Riverview Improvement Co., Natl. City Bldg., Cleveland, R. B. Thullen, Mgr., awarded the contract for the construction of a 6 story apartment building on Detroit and Blount Rds., here, to the Fleisher Constr. Co., Builders Exch., Minneapolis, Minn. Estimated cost $1,000,000. Equipment detail not reported. Former contract cancelled.

Wis., Franksville—The Frank Pure Food Co., 288 East Water St., Milwaukee, awarded the contract for the construction of 1 story additions to its factory, including a 48 x 82 ft. addition to main building, 90 x 192 ft. vat house, 30 x 40 ft. boiler house, and a 28 x 30 ft. pump house, here, to H. Danischefsky, 1484 Humboldt Blvd., Milwaukee. Estimated cost $110,000. The contract for boilers was awarded to Freeman Mfg. Co., Racine. The owner is in the market for special krout canning machinery, belting and shafting.

Que., Montreal—Henry Morgan & Co., Ltd., St. Catherine St., (department store), awarded the contract for the construction of a 75 x 160 ft. power house on Aylmer St. to the Henry Morgan Co., Beaver Hall Hill. Estimated cost $150,000.